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Research Article

# Development of a Critical Skills Assessment for Military Medical Field Settings

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## Abstract

**Objectives:** To develop a method of measuring medical decision making in a military field setting that would allow an evaluation of the impact of sleep deprivation, fatigue, and other stressors on critical skills deterioration.

**Methods:** Thirty-seven students who were enrolled in a Doctor of Nursing Practice (DNP) program or a Bachelor of Science in Nursing (BSN) program participated in this study. Over the course of three days, student participants were sent five questions in the morning and five questions in the evening. On the fourth day, students were sent 10 questions in the morning and 10 questions in the evening. DNP students received medication calculation questions and BSN students received Basic Life Support (BLS) questions. All questions were drawn from standardized test bank sources, were multiple choice, and were thoroughly reviewed by the research team for relevant content prior to study testing.

**Results:** Twenty-five (50%) and twenty-eight (56%) of the 50 BLS and medication calculation questions met the selection criteria of average response times between 10 and 50 seconds and accuracy of at least 80%. From these, 16 questions were selected from both sets with smaller standard deviations, minimum response times of at least 5 seconds and maximum response times less than 90 seconds.

**Implications:** In order to test the impact of sleep deprivation, fatigue, or any other stressors on critical decision making skills of military medical personal during field training operations it was necessary to develop a test battery of questions that are sensitive enough to detect variation due to human factors. Our study accomplished this objective, and the resulting medication calculation and BLS questions can be used to readily assess deterioration in critical decision making skills within a field setting.

**Key Words:** Critical Skills, Disaster Training, Sleep and Fatigue

## Introduction

A two-year study is currently underway to examine the impact of sleep deprivation and fatigue on decision making during United States (US) National Guard disaster training exercises, and therefore, the simulated conditions of a real disaster. As part of this study, participants recruited from a group of US National Guard medical personnel participating in a disaster response training and evaluation exercises will complete "Critical Skills" test questions. These questions must be in line with their skill set and training, and will be administered four times a day throughout their disaster exercise training as they simulate mass casualty, triage, and military mission-driven skills. Prior to starting this two-year study, our research team was faced with the challenge of identifying a method of measuring medical decision making in a military field setting that would be non-disruptive to the disaster response training exercises underway. The process by which we developed a method of measuring medical decision making in a military field setting is described in this manuscript, together with the resulting bank of test questions.

## Literature Review

Evidence from the research literature suggests examining critical skills that medical personnel are expected to perform under duress (e.g. fast pace/urgency, environmental [heat/humidity] stressors, sleep restriction and fatigue) is a plausible approach to evaluating the effects of these stressors on clinical performance [1-10]. For example, Saadat et al. noted that partial sleep deficiency significantly impaired cognitive skills, which has direct implications on patient safety [1]. Jackson et al. examined the effect of sleep loss on neurocognitive tasks using simulated driving performance by measuring reaction time [2].

Two studies reported on the impact of sleep/wake habits on academic performance in medical students [3,4]. Furthermore, Amirian used laparoscopic simulation to examine the effect of fatigue on psychomotor performance and cognitive tests for a group of surgeons [5].

Pucher et al. examined time to completion of assessment care process as well as errors in care [6]. In-line with the outcomes used in this and other studies [1], as a measure of critical skills performance, we chose to have participants complete knowledge-based questions recording both time to completion and accuracy of completion. Completion of a single, unique question at several time points over the course of the disaster exercises provided a feasible and nonintrusive method for measuring decision making ability. In line with their knowledge and skill set, the decision was made to have Air National Guard participants who are nurse practitioners, nurses, physicians, or physician's assistants complete medication related questions; and medics (EMT-trained) complete Basic Life Support (BLS) related questions.

## Study Aim

The purpose of this paper is to describe our process for determining the set of medication calculation questions and BLS questions used in the larger two-year study and the data supporting the selection of these questions. These questions determine our "Critical Skills Assessment" for our larger sleep health study. Our goal was to identify a set of 16 medication calculation questions and 16 BLS questions that, under non-stressful conditions, were of similar difficulty (measured by accuracy) for participants to complete and took participants similar amounts of time to complete (measured by response time) under ideal, or normal working circumstances. Our target was to identify a set of 16 questions, which would facilitate evaluation of the impact of sleep degradation and fatigue on decision making as measured by changes in response time and accuracy across four assessment times per day of a four-day disaster drill training exercise.

## Methods

### Study Design

Fifty medication calculation test questions and 50 BLS test questions (multiple choice) were taken from standardized test bank sources. The questions were reviewed by the research team comprised of a doctoral prepared registered nurse (RN), a Family Nurse Practitioner and military nurse, a Master's prepared RN, and a second military nurse officer (MN/RN) for relevant content. Based on the team's initial impressions, the selected questions were of a similar degree of difficulty.

### Participants/Setting

After receiving an exempt determination from the university institutional review board, students enrolled in during the Summer 2016 and Spring 2017 sessions in the Doctor of Nursing Practice (DNP) program and the Bachelor of Science in Nursing (BSN) program (most of whom were in the RN-Baccalaureate program and had an RN license) were recruited as volunteers for a study in which they would be asked to complete one of the sets of 50 questions. Students were invited to participate via an email sent through the course learning management system site and instructor course announcements. Prior to the invite, the principal investigator visited several of the classes and provided a five minute overview about the study, explaining the study requirements and the expected time commitment that would be required by participants. All students who enrolled received an initial email inviting them to participate along with a link to a document explaining the study. Students interested in participating consented by clicking on the appropriate box.

DNP students were enrolled as proxies for the military medical officers (e.g. RNs, Pharmacists, Nurse Practitioners/Physician Assistants, CRNAs [Nurse Anesthetists] and physicians) and were asked to complete medication calculation questions. BSN students were enrolled as proxies for the military medics and were asked to complete the BLS questions. Over the course of three days, student participants were sent five questions in the morning and five questions in the evening. On the fourth day, students were sent 10 questions in the morning and 10 questions in the evening.

### Ethical Considerations

This study was determined to be exempt by the University Institutional Review Board. Participants were recruited from general emails and class announcements by the PI and the research team. Confidentiality was maintained as responses were not linked to identifiers through the Qualtrics platform.

### Data Analysis

Qualtrics Survey Research Suite™ was used to send participants a link for each survey containing either 5 or 10 test questions. Qualtrics is a platform for creating and distributing online surveys. The platform records response data, performs analysis, and reports on the data. Collected data is protected through the platform via firewalls, regularly scheduled vulnerability scans, and a Transport Layer Security (TLS) encryption for all transmitted Internet data. Surveys could be completed on a smartphone, tablet or computer. The participant's response to the question and the response time (measured in seconds) was captured in Qualtrics.

For analysis, data were exported from Qualtrics into the IBM SPSS Statistics (version 24) package. For the 50 medication calculation questions and the 50 BLS questions separately, the percentage of students correctly answering each question and the mean, standard deviation, minimum and maximum response time for each question were calculated. The mean response time and the accuracy for the BLS and medication calculation question sets were graphed to identify questions above and below agreed upon thresholds established by the Research Team. Under non-stressful conditions, average response times of 30 seconds or less along with a minimum of 80% accuracy were acceptable. The minimum response time (greater than 5 seconds), the maximum response time (less than 90 seconds) and the standard deviation (smaller being better) were also examined to exclude questions from inclusion in the final sets of 16 questions-the number of questions required for the larger two-year study.

Using the subset of questions meeting all these criteria, the research team re-reviewed the questions eliminating additional questions that upon second review had problematic or confusing wording. The final set of 16 medication calculation questions and 16 BLS questions were selected from the reduced set of questions with desirable properties for mean response time and accuracy. Due to the small sample sizes, no equivalency hypothesis testing could be performed that would achieve a minimum of 80% power.

## Results

Fifty-seven students from both programs consented to participate of whom 37 (22 DNP, 15 BSN) completed the study (Table 1). Among the 20 students who consented to participate but did not complete the surveys, 7 students failed to receive the survey links and 13 students changed their mind. Four students had none (Associate Degree graduates awaiting to take NCLEX exam) to less than 1 year as an RN. Twelve (32%) participants reported that they had been practicing as an RN for 1-5 years and 20 (54%) participants have been an RN for 6 or more years.

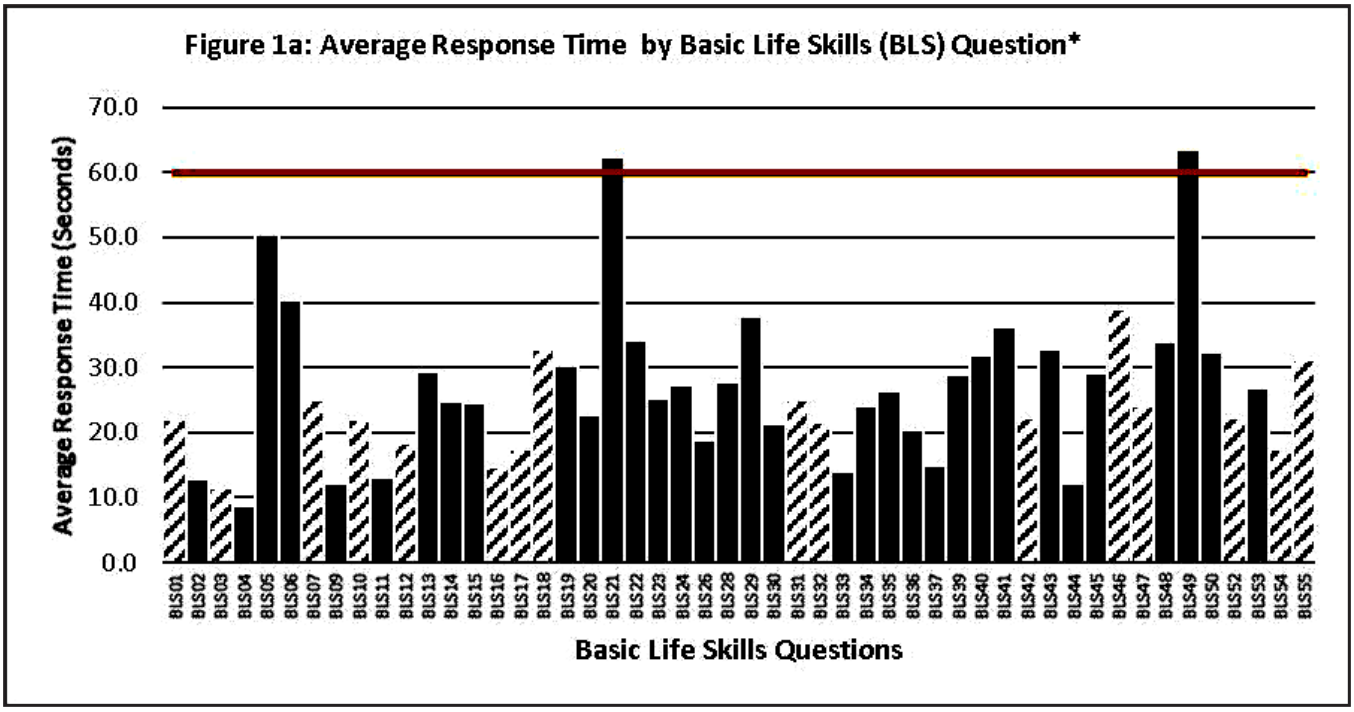
Among the 50 BLS questions tested, average response rates fell below 60 seconds for all but two of the questions and accuracy was at least 80% for 29 (58%) of the questions (Figure 1). Narrowing the selection criteria to both average response times between 10 and 50 seconds and accuracy of at least 80%, 25 (50%) of the BLS questions met these criteria. Giving priority to questions with smaller standard deviations, minimum response times of at least 5 seconds and maximum response times less than 90 seconds, these 25 questions were reviewed by the research team for clarity of wording, from which the final 16 BLS questions were selected (Table 2).

Among the 50 medication calculation questions tested, average response rates fell below 60 seconds for 33 (66%) questions and accuracy was at least 80% for 43 (86%) of the questions (Figure 2). Narrowing the selection criteria to both average response times between 10 and 50 seconds and accuracy of at least 80%, 28 (56%) of the medication calculation questions met these criteria. Similar to the process followed for selecting the final BLS questions, priority was given to questions with smaller standard deviations, minimum response times of at least 5 seconds and maximum response times less than 90 seconds. These 28 questions were reviewed by the research team for clarity of wording, from which the final 16 medication calculation questions were selected (Table 2).

**Table 1: Education and Professional Experience of Participant[a]**

| Characteristics | Critical Skills Group | |
|---|---|---|
| | Basic Life Support (n=15) | Medication Calculation (n=22) |
| Registered Nurse (RN)[b]: | | |
| Yes | 14 (93%) | 21 (95%) |
| No[c] | 1 (7%) | 0 (0%) |
| Declined | 0 (0%) | 1 (5%) |
| Licensed RN: | | |
| Yes | 14 (93%) | 21 (95%) |
| No | 1 (7%) | 0 (0%) |
| Declined | 0 (0%) | 1 (5%) |
| Years practicing as a nurse: | | |
| none | 1 (7%) | 0 (0%) |
| <1 year | 3 (20%) | 0 (0%) |
| 1-5 years | 5 (33%) | 7 (32%) |
| 6-10 years | 3 (20%) | 8 (36%) |
| >10 years | 3 (20%) | 6 (27%) |
| Declined | 1 (7%) | 1 (5%) |
| Program of Study : | | |
| RN-BSN | 13 (86%) | 1 (5%) |
| Pre-Licensure | 1 (7%) | 0 (0%) |
| DNP/MN | 1 (7%) | 21 (95%) |

[a]A total of 57 students consented to participate. Among these students, 37 students completed skills assessment surveys
[b]All participants were licensed RNs except for one in the Basic Life Support group.
[c]Participant was enrolled in a prelicensure program



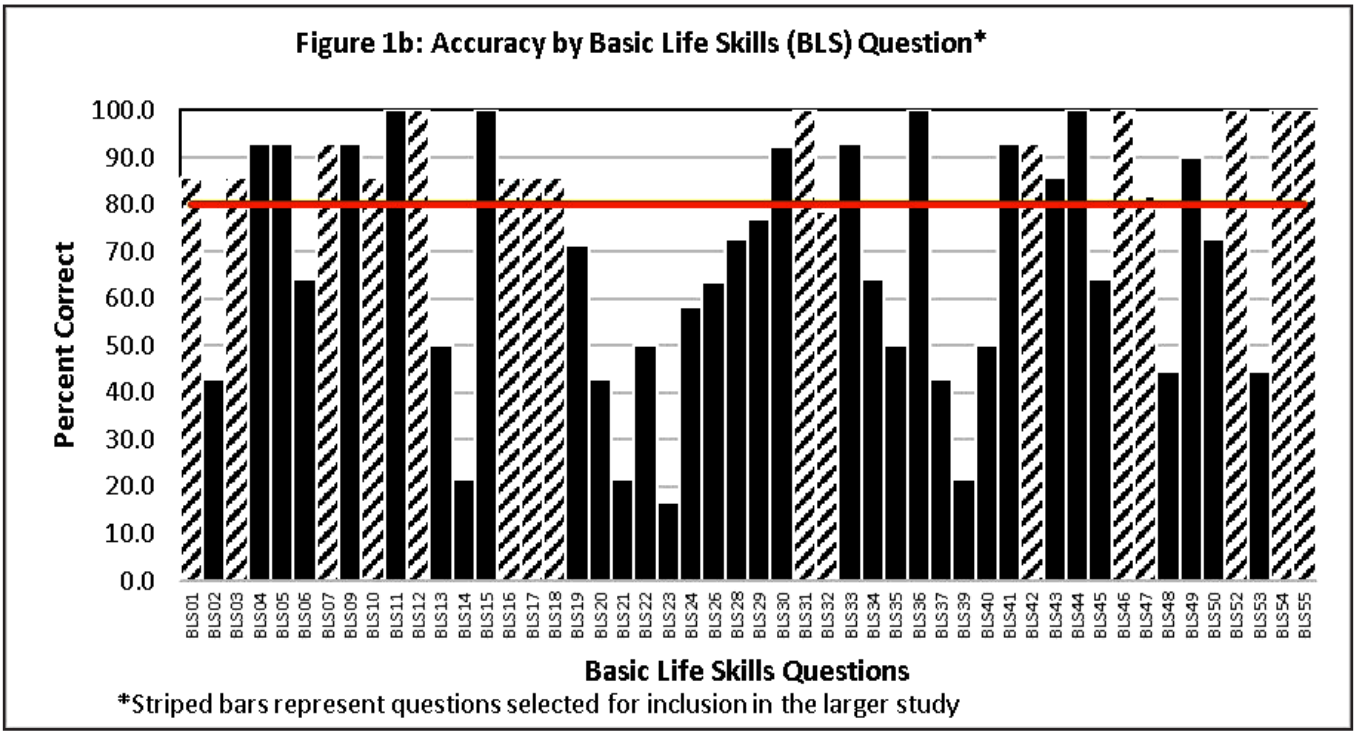
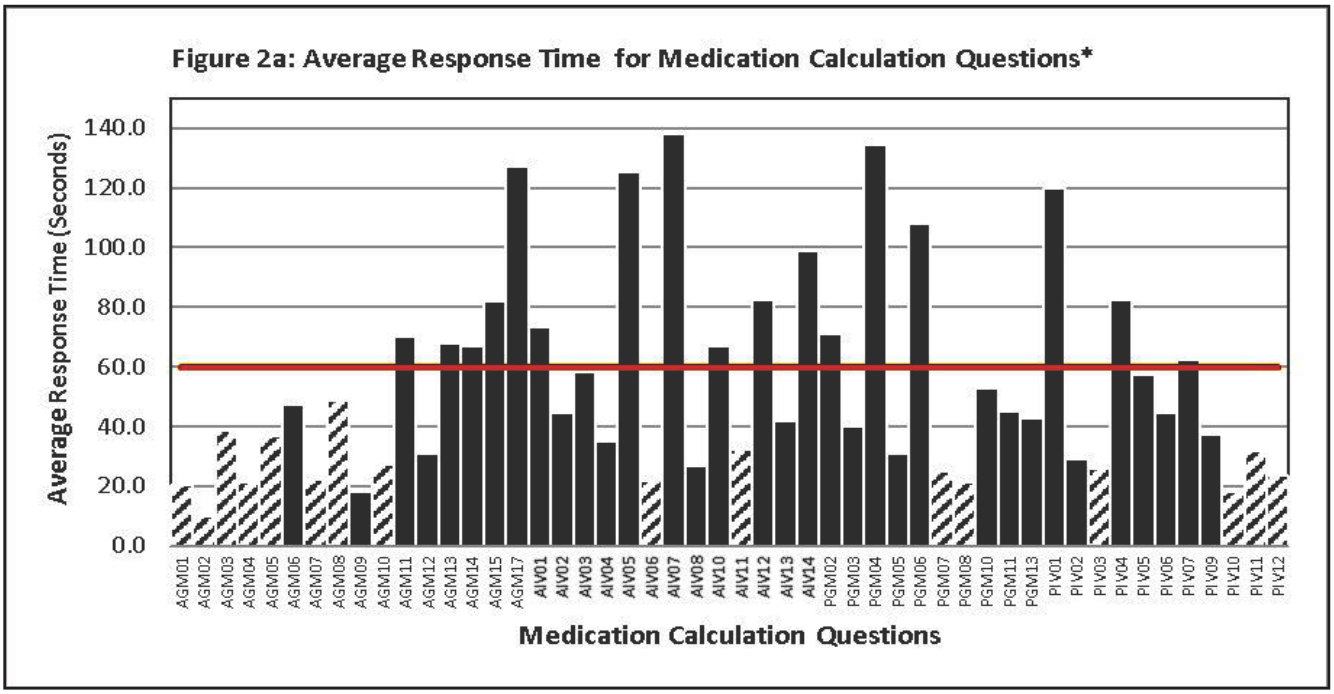
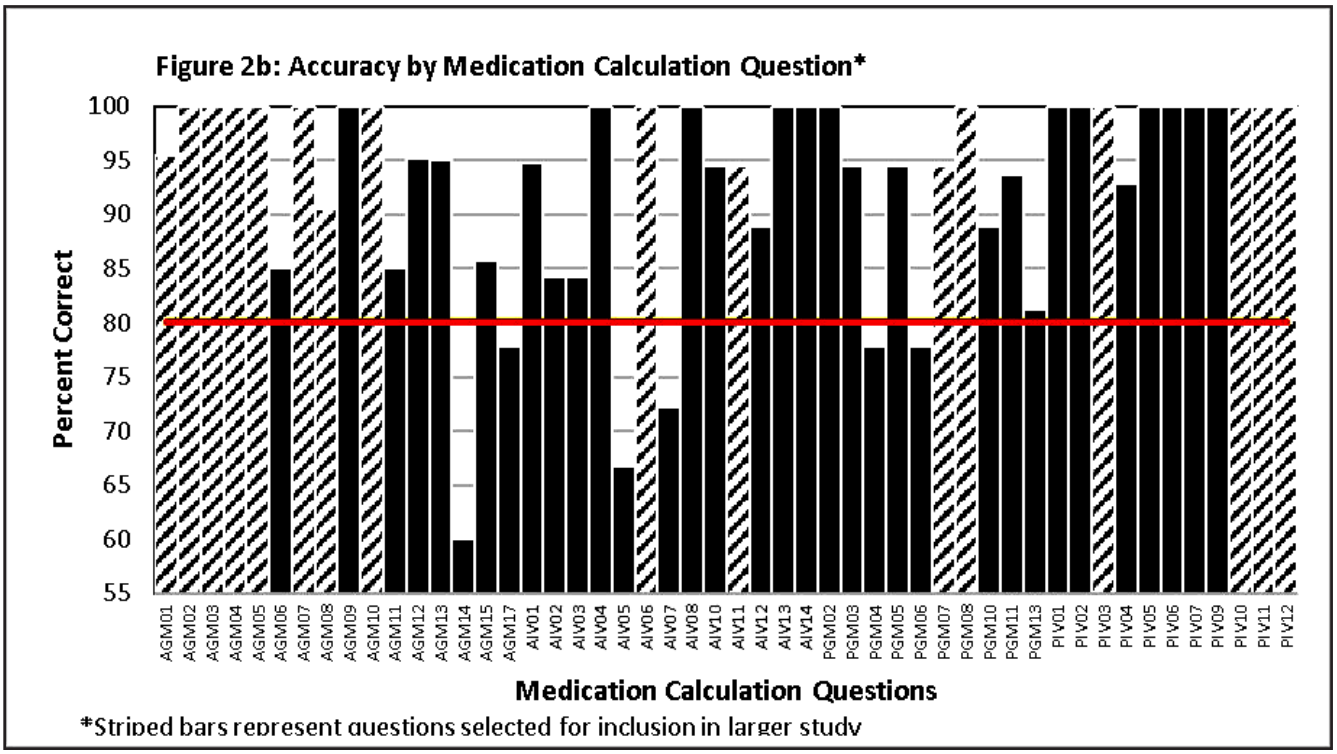



**Table 2: Sample Basic Life Support and Medication Calculation and Questions Selected for Inclusion**

| Category | Question | Answers |
|---|---|---|
| BLS1. | Critical characteristics of high-quality CPR include which of the following? | a. Starting chest compressions within 10 seconds of recognition of cardiac arrest<br>b. Allowing complete chest recoil after each compression<br>c. Minimize interruptions of CPR<br>**d. All of the above** |
| BLS3. | The compression to ventilation ratio for the one-rescuer giving CPR to victims of ANY age is: | a. 30:1<br>**b. 30:2**<br>c. 15:1<br>d. 15:2 |
| BLS7. | You are alone when you encounter a patient in what appears to be Cardiac or respiratory arrest. What are the first three steps you should take to stabilize the patient? Check for danger, _____, and send for help. | a. Establish IV access<br>b. Insert an advanced airway<br>**c. Check for response**<br>d. Start CPR |
| **Adult General Medication Calculations**<br>AGM01. | Order: Hydroxyzine (Vistaril) 100 mg IM q6h<br>Available: Vistaril 50 mg/1 ml<br>How many ml should be administered? | a. 0.5 ml<br>b. 1 ml<br>c. 1.5 ml<br>d. **2 ml** |
| AGM02. | Order: Codeine Sulfate 60 mg PO q6h PRN. Available in 30mg tablets.<br>How many tablets should be administered? | a. 1 tablet<br>b. 1.5 tablets<br>c. **2 tablets**<br>d. 1.25 tablets |
| AGM03. | Order: Verapamil 60mg PO q.i.d<br>Available: Verapamil tablets are available in three forms namely 120 mg and 80 mg and 40 mg tablets. The 120 mg and 80 mg tablets are scored. Which strength of verapamil should be selected? | a. **120 mg: half tab**<br>b. 80 mg: one tab<br>c. 40 mg: one and a half tabs<br>d. 120 mg: one and a half tabs |
| **Adult IV Medication Calculations**<br>AIV06. | How long will a 550 ml bag of NS take to infuse at a rate of 25 ml/hr? | **a. 22 hours**<br>b. 24 hours<br>c. 18 hours<br>d. 16 hours |

| | | |
|---|---|---|
| **Pediatric General Medication Calculations**<br><br>PGM07. | An 18 kg child has an order for Motrin 150 mg PO q6-8h PRN pain. The available form is 100 mg/5 ml. How much will you give per dose? | a. 5 ml<br>**b. 7.5 ml**<br>c. 15 ml<br>d. 10 ml |
| **Pediatric IV Medication Calculations**<br><br>PIV03. | You have an order for maintenance fluids for a pediatric patient for Normal Saline 1250 ml/day. Calculate how much volume to give per hour: | a. 25 ml/hr<br>b. **52 ml/hr**<br>c. 36 ml/hr<br>d. 48 ml/hr |



## Discussion

Our study objective was to rapidly develop a method of measuring medical decision making in a military field setting that would allow an evaluation of the impact of sleep deprivation, fatigue, and other stressors on critical skills deterioration. The purpose of this paper was to describe our approach in developing a simple, non-intrusive measure of medical decision making. Demands of our larger study and the urgency of needing information to guide which questions to be employed required us to gather preliminary evidence regarding the similarity of the response time and difficulty of the questions used to measure medical decision making. As such, we used Doctor of Nursing Practice (DNP) and Bachelor of Science in Nursing (BSN) students as a proxy for National Guard medical personnel. We tested students on a bank of 50 medication calculation questions and 50 Basic Life Support (BLS) over the course of four days, and consequently selected a reliable subset of 16 medication calculation questions and 16 BLS questions. The implications of our study for testing the impact of sleep deprivation, fatigue and other stressors on military medical personnel critical decision making are numerous.

First, due to the extreme nature and setting of National Guard disaster simulation training exercises, limiting participant burden is a critical consideration. For example, it is not feasible to interrupt the training exercise to test medical personnel for fatigue using a traditional measure such as the psychomotor vigilance test (PVT). The PVT is done individually on a dedicated computer or handheld device, and can take either 3 minutes, 5 minutes, or 10 minutes per person. The time it would take to rotate all disaster trainees through the PVT several times per day excludes this test measure as a feasible option for assessing trainee fatigue. In a similar manner, testing trainees on simulation skills is time consuming and can be disruptive to the training exercise [2,5]. Additionally, disaster simulation training exercises are conducted in field conditions (hot/wet/cold/snow), which are not often conducive to traditional testing modalities. We believe that medication calculation and BLS questions provide a natural solution. Each question takes less than a minute to answer, can be easily accessed via a handheld device or can be implemented using traditional pen and paper format, and minimizes participant burden during a stressful and time consuming field exercise.

Second, our process of selecting a bank of medication calculation and BLS questions has resulted in a test measure that we hypothesize is sensitive enough to detect changes in critical decision making skills based on sleep deprivation and fatigue. Subsequent research is needed to determine the sensitivity of these questions. Our larger military study (and impetus for conducting this pilot study) will provide us with greater insight into the validity of this test method. We tentatively argue however that using medication calculation and BLS questions as a method of measuring critical decision making skills-and specifically the set of questions we identified here-will represent a more effective and efficient method than has been previously available.

## Limitations

Several limitations need to be addressed in the current study. First, our initial intention was to examine participants' response times and accuracy in a more fatigued state by having them answer questions in the evening (after work) and after a block of 10 questions (compared to five). We hypothesized that questions answered in the evening or in a block of 10 would be associated with lower accuracy and longer response times. However, we did not have information on the participants' varying work schedules (day shifts and rotating swing shifts or night shifts). As such questions completed in evening could have been after the participant completed work or prior to the participant leaving for work. A future improvement to our study design would be to collect information on work schedule and standardize when questions are sent to participants around their work schedule.

Second, our approach was limited by the numbers of DNP and BSN students available and willing to participate. As such, we limited the presentation of our findings to descriptive analyses that describe and support our approach. A larger study is required to merit a more detailed reporting of metrics regarding the variability of these data.

## Conclusion

This study demonstrated that medication calculation and Basic Life Support (BLS) questions may be an effective, non-disruptive tool to measuring medical decision making capacity in a military field setting such as simulated disaster training exercises. From a set of 100 standardized questions selected, 32 questions (16 medication calculation and 16 BLS) met criteria with smaller standard deviations, minimum response times of at least 5 seconds and maximum response times less than 90 seconds, and will be utilized in our larger National Guard medical personnel effects of sleep disruption on operational performance in simulated disaster training exercises.

## Implications for Practice

Due to the nature of high military operational tempo, variable environmental conditions, mental stress and physical fatigue, the development of a valid method to evaluate the effects of fatigue on critical thinking skills of medical members of National Guard disaster response teams is invaluable. Utilizing technology to perform an assessment of a military member's cognitive ability and level of fatigue is aligned with trends of increasing technology usage in both modern medicine and the military alike. Furthermore, the study not only provides a cost-effective method to measure the effects of fatigue on decision making, but also limits negative impacts on the overlying mission and training exercise by not requiring extensive time or distraction from the participants. While the tool that has been developed does not evaluate the use of motor skills, such as performing an insertion of an intravenous line, it does assess cognitive function that is every bit as critical in providing crucial medical

care. Utilization of BLS and medication calculation questions not only assesses the participants' ability to appropriately make potentially life-saving decisions, but analyzes how well they are equipped to do so under various levels of fatigue. Once this study has been implemented in the military capacity, it is anticipated that results may impact leadership decision making with respect to consideration of fatigue and the resultant ability of members to perform critical assessments and come to clear conclusions. These outcomes may therefore influence future work-rest cycles of National Guard medical personnel during exercises and real-world events alike to ensure safe, quality, effective care is being delivered.

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