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UNITED STATES ARMY AEROMEDICAL RESEARCH LABORATORY

# Expert Panel Feedback on Fatigue Impacts on Cognitive and functional Performance of Flight Paramedics

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**14. ABSTRACT**

The objective of this expert panel was to identify medical scenarios, tasks, and measurable outcomes for use in an upcoming prolonged en route casualty care study. The discussion yielded key takeaways such as the type of tasks to employ (those requiring critical thinking skills such as medication and dosing calculations, ventilator management, troubleshooting and response to alarms, and documentation), and the implementation of multiple patient scenarios and extended durations to exacerbate fatigue effects.

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## Introduction

Research on human performance requires careful consideration of what to measure, when, how, and under what conditions. The applicability, precision, and interpretability of performance outcomes is a key element in determining the utility of the study's findings. In applied research, scenarios and tasks are often more complex than in basic research, and tailored to specific sub-populations or environments, hence, less likely to be validated for broad applicability. The focus of this paper is the process used to develop meaningful performance metrics and scenarios when no such established metrics or tasks exist. Specifically, this report describes an expert panel conducted to inform the development of performance tasks and measures on a study of flight paramedic performance under conditions of fatigue and sustained wakefulness.

Medical providers in both civilian and military environments are expected to maintain performance and remain alert for extended durations, often sacrificing much-needed rest to treat patients. Military medical providers encounter prolonged casualty care (PCC) when demand exceeds availability of resources. The impacts of fatigue and extended durations on medical providers and performance have been studied for decades using a wide variety of outcome measures and tasks (Gates et al., 2018). Much of the research has been observational in nature, employing cross-sectional study designs primarily in hospital settings and measuring patient outcomes, surgical efficiency, collecting self-reported wellness and stress levels in providers, and provider work and life satisfaction. Many studies also include the Psychomotor Vigilance Task as an objective fatigue-related metric. However, no studies in the Gates et al. review included combat medics or prolonged casualty care. Our assessment of the literature did not yield specific studies of sleep deprivation on flight paramedic performance under sustained wakefulness.

A review of the literature on combat medic performance yielded 48 studies between 2011 and 2021 employing medical simulations (Knisely et al., 2023). The most commonly employed procedures in these studies are: hemorrhage control (included in 18 studies), surgical airway management (15 studies), patient examination (13 studies), thoracostomy (11 studies), vascular access (9 studies), and nonsurgical airway management (9 studies). The most commonly reported outcome measures were timing (completion and response times), subject matter expert (SME) graded pass/fail of skill execution, and self-reported measures of efficacy and accuracy. Only 3 of 48 studies included in the review assessed errors as an outcome measure. The methodology employed by the U.S. Army Aeromedical Research Laboratory (USAARL) Patient and Casualty Evacuation Research (PACER) Group research aligns with the review findings (Conti et al., 2019; Kroening et al., 2022; Kroening et al., 2023; Enzor et al., 2025). Specifically, the PACER Group employs medical simulation manikins in laboratory-based scenarios, and utilizes time to complete, response times, and pass/fail determinations as outcomes. Additional review did not yield research employing combat medic scenarios that demonstrate vulnerability to fatigue (sleep deprivation).

Following the evaluation of the literature, it was determined that additional information was needed in order to develop simulated combat medic scenarios where performance would be vulnerable to fatigue or PCC effects. Thus, an expert panel was employed to draw upon practical experience to produce realistic and meaningful scenarios with outcomes that are observable, measurable, and sensitive to fatigue effects.

## Expert Panel

Seven military medical care providers (representing U.S. Navy, Army, and Air Force) with varying levels of training and experience with en route care participated in the panel. All participants were provided with read-ahead materials to orient them to the study as well as the method used by the research team to develop medical scenarios (Kroening et al., 2025).

The expert panel was held virtually, using Microsoft Teams. The research team and USAARL's Science Program Director led the discussion.

The session began with a description of how patient scenarios are developed by the USAARL PACER research team. This information was also provided in the read-ahead materials. Specifically, to create a new patient scenario, a medical SME from the research team must first request de-identified patient records from the Joint Trauma System (JTS) Department of Defense (DoD) Trauma Registry by filling out a Data Request Form. Once the SME receives the records, they extract essential information, such as the mechanism of injury, vital signs, and injury types, to form the basis of a patient scenario. A synthesized JTS case summary example is provided in Figure 1. The research team then uses this extracted data to design scenarios tailored to the study's requirements. These scenarios are reviewed by the medical SME for accuracy and realism. Following this review, additional documents are created, such as a Tactical Combat Casualty Care (TCCC) card (Department of Defense [DD] Form 1380) and a critical care medical task list (examples provided in Figures 2 and 3). The TCCC card informs study participants about the simulated patients they will be treating (i.e., study participants review at the start of a data collection session). The critical care medical task list may be used by a medical validator or proctor during data collection to record whether the study participant completes the necessary tasks to treat the simulated patient. Decompensation events are typically built into the scenarios yielding a response time measure to the outcomes of interest.

The USAARL team also bracketed the discussion with an assumption that the level of provider that will be participating in this fatigue study will be a Flight Paramedic (68WF2). The military occupational specialty (MOS) of 68W is a Combat Medic Specialist. The additional skills identifier of F2 indicates specialized training with emergency care on board Army aircraft and trained to the Nationally Registered Paramedic (NRP) level.

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| Patient 1 (IED Blast Injury) Summary | | | | |
|---|---|---|---|---|
| **Patient Status** | **Starting Vitals** | **Injury Descriptions** | **Treatments** | **Medication** |
| Triage level: urgent<br><br>Starting status:<br><br>Lethargic | IBP: 130/86<br><br>Temp: 98.0<br><br>HR: 94<br><br>RR: 18<br><br>$SpO_2$: 100 | • GSW to L lateral thigh<br>• GSW to LLE<br>• GSW to RLE<br>• Laceration to bilat hands<br>• FX in L hand<br>• FX R tib/fib<br>• Open FX L tibia<br>• Arterial bleed R lower extremity | • TQ on L leg<br>• TQ on R leg<br>• 18G IV RUE<br>• Kerlix dressing on open FX | • 50 mg Ketamine |

| Patient 1 (IED Blast Injury) Decompensation Events | | | |
|---|---|---|---|
| **Time** | **Alarm Type** | **Value** | **Cause of Alarm** |
| 02:00 | $SpO_2$ low | 86% | Hemorrhagic shock |
| 23:00 | BP low | 79/49 | Blood loss |

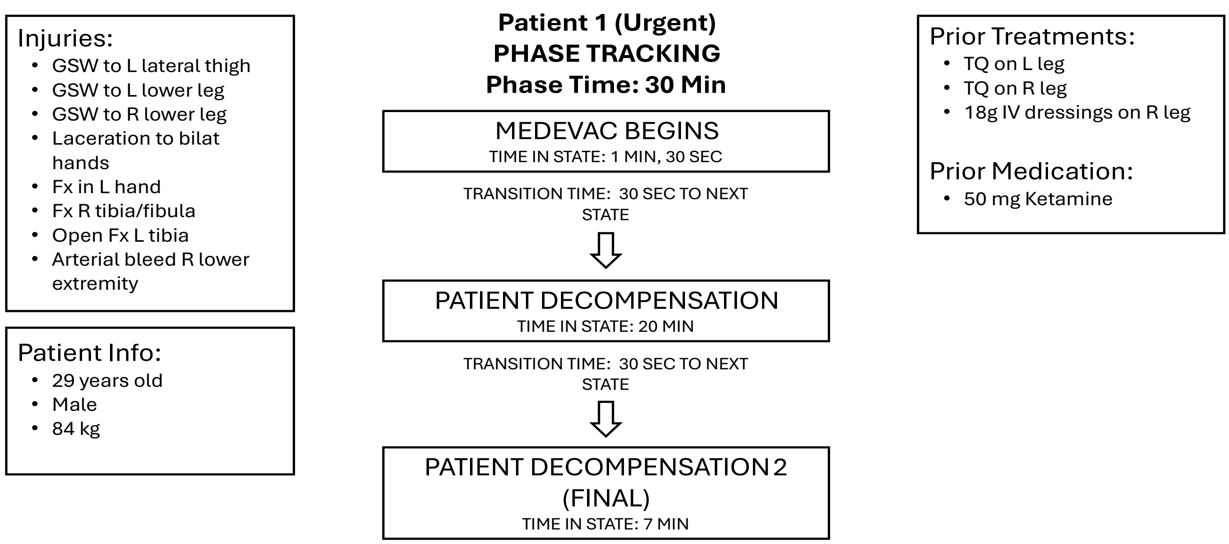


*Figure 1.* Example of a synthesized Joint Trauma System case summary with decompensation events. Abbreviations and acronyms are defined in the Appendix.

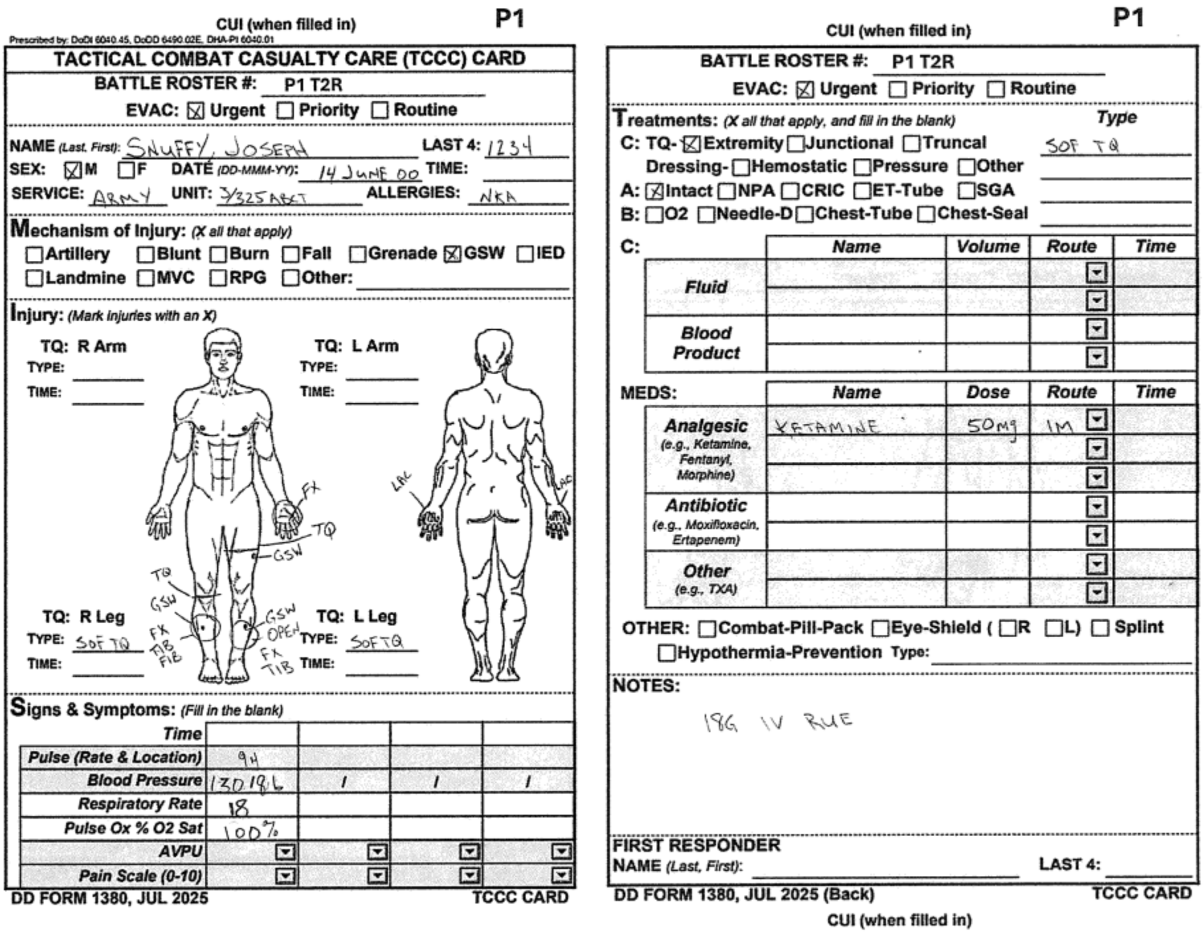

*Figure 2.* Example of a generated TCCC card. Abbreviations and acronyms are defined in the Appendix.

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**Critical Care Task List:**

Critical criteria:

- ☐ Must do adequate MARCH.
  - ☐ Massive bleeding control
    - ☐ Reassess previously placed TQs.
  - ☐ Airway
  - ☐ Respiratory
  - ☐ Circulation
  - ☐ Hypothermia care
  - ☐ Eye injuries
  - ☐ Spinal motion restriction
- ☐ Properly oxygenate PT.
  - ☐ Good $SpO_2PSO_2$ - >92% then give supplemental oxygen
- ☐ Give PT TXA.
  - ☐ Dosage: 2g IV
- ☐ Identify possible internal bleeding and start proper blood administration.
  - ☐ Steps for blood administration
    - ☐ Start IV
    - ☐ Administer blood
    - ☐ Blood warmer
    - ☐ Pressure bag
    - ☐ Check for allergic reaction

Non-Critical Criteria:

- ☐ Splint FXs.
  - ☐ Splint left hand FX
  - ☐ Splint right Tib/Fib FX
  - ☐ Splint open left Tib FX
- ☐ Dress wounds.
- ☐ Re-address pain management.
- ☐ Measure abdomen for progression of internal abdominal bleeding.
- ☐ Additional IV site.

Bonus Points: Downgrade TQs to pressure dressings if applicable

*Figure 3.* List of critical care tasks. Abbreviations and acronyms are defined in the Appendix.

The research team then presented some examples of the types of outcomes of interest typically employed in not only combat casualty care research but also fatigue and sleep deprivation studies. The team discussed the measures outside of performance that are collected to validate the level of fatigue experienced (Table). Finally, the team led the panel through discussion of medical scenarios, skills/tasks, and measurable outcomes.

*Table 1.* Examples of Outcome Measures

| Data Element/Variable | Task/Instrument | Dependent Variables/Units |
|---|---|---|
| *Response time* | Medical simulation | Minutes and seconds |
| *Treatment time* | Medical simulation | Minutes and seconds |
| *Device time* | Medical simulation | Minutes and seconds |
| *Sustained attention performance* | Computerized cognitive task | 1) Speed (ms)<br>2) Accuracy |
| *Subjective sleepiness* | Questionnaire | Subjective rating |
| *Video* | Medical simulation | 60 frames per second |
| *Expert ratings of performance/checklist of critical and non-critical tasks (see Figure 3)* | Medical simulation | 1) Checklist used by two SME observers, independent<br>2) Pass/fail of each task |
| *Alertness/vigilance* | Psychomotor Vigilance Task | 1) Reaction time (ms)<br>2) Lapses (ms) |

## Discussion

Through review of the transcript of the expert panel discussion, three key themes emerged: tasks/skills likely to be impacted by fatigue, the interaction between fatigue and other stressors (e.g., workload), and time-on-task fatigue.

The discussion centered on critical thinking skills required in medic performance. The consensus from the panel was that technical skills are not likely to be susceptible to fatigue-induced errors given that conduct is rote memory and does not require much "thinking." The group consensus on the best tasks for inclusion are as follows:

- Medication and dosing calculations
- Ventilator management
- Troubleshooting and responses to alarms
- Documentation

Another key element of the discussion was the interaction between fatigue and a second variable to further strain the participants' performance level. The level of workload experienced, such as that associated with multiple patients, would further attenuate effects. Specifically, the introduction of multiple patients would cognitively tax the medic, likely exacerbate the impact of fatigue, and ultimately increase the likelihood of errors. Past USAARL research has demonstrated that the number of patients is an effective workload manipulation and increases performance errors observed (Conti et al., 2019).

In a similar vein, it was suggested that the transport time (or time attending to the patient in the aircraft) could be extended, which would introduce a third element impacting their performance, time-on-task fatigue. The panel indicated that the "adrenaline rush" experienced at the onset of a scenario will likely preserve performance. However, this will wane as the patients are stabilized and participants begin non-emergency tasks such as documentation and monitoring for alarms. Typically, USAARL studies employ 30- to 60-minute medical simulation scenarios in en route care research, which is resource intensive for both the participants and the research teams. Anecdotal evidence from the research team indicated that participants tend to "relax" approximately 30 to 40 minutes into a scenario at which point a decompensation event may be advantageous to capture procedural errors. Also, at this point in the scenario, the participant will likely begin non-emergency tasks including documentation which will likely also be susceptible to fatigue-induced errors. Longer durations will be considered but may be limited given resource constraints or logistics.

## Conclusion

The expert panel yielded insights into the development of medical simulation scenarios to employ in an upcoming sustained wakefulness, akin to PCC, study. The following are the key takeaways and recommendations:

Tasks that require critical thinking skills are more likely to be susceptible to fatigue-induced errors than performance of rote technical skills. Suggested tasks are medication and dosing calculations, ventilator management, troubleshooting and response to alarms, and documentation.

Workload, specifically the number of patients, is a worthwhile manipulation to attenuate the effects of fatigue. Errors in non-critical tasks (such as documentation) are most likely to be demonstrated.

Extended duration or prolonged time-on-task would increase the likelihood of errors. USAARL PACER research studies have employed 30- to 60-minute scenarios in the past, which are taxing not only for the participant, but also for the research team. Adoption of this recommendation will be determined by logistical and resource constraints.

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## Appendix. Acronyms and Abbreviations

| | |
|---|---|
| BP | Blood Pressure |
| DoD | Department of Defense |
| Fx | Fracture |
| GSW | Gunshot Wound |
| HR | Heart Rate |
| IBP | Invasive Blood Pressure |
| IV | Intravenous |
| JTS | Joint Trauma System |
| kg | Kilograms |
| L | Left |
| MEDEVAC | Medical Evacuation |
| mg | Milligrams |
| ms | Milliseconds |
| PACER | Patient and Casualty Evacuation Research |
| PCC | Prolonged Casualty Care |
| PT | Patient |
| R | Right |
| RR | Respiration Rate |
| SME | Subject Matter Expert |
| $SpO_2$ | peripheral Oxygen Saturation |
| TCCC | Tactical Combat Casualty Care |
| TQ | Tourniquet |
| TXA | Tranexamic Acid |
| USAARL | U.S. Army Aeromedical Research Laboratory |

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