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Joint Federal Research Funding for Military Personnel and Veterans

Project Report Summary Template

Funding Opportunity
Battlefield Evacuation Optimization during a Mass Casualty Incident
Brief Overview
This project developed and evaluated decision-support tools to improve battlefield medical evacuation (MEDEVAC) operations during mass casualty incidents. Researchers compared rule-based and optimization-based dispatching approaches and developed a Markov Decision Process (MDP) model to improve casualty survival while considering fairness and equitable access to care.
What is this Research About? Battlefield medical evacuations are critical for ensuring injured personnel receive life-saving treatment within the "golden hour." During mass casualty incidents, commanders must make complex decisions under uncertainty, balancing casualty survival, resource availability, and operational readiness. This research examined how advanced optimization and decision-making models can improve MEDEVAC dispatch decisions compared with traditional approaches that simply send the nearest available asset.
What did the Research Do? Researchers developed two complementary modelling frameworks: • A simulation-based platform that evaluated five dispatch policies, including two rule-based approaches and three optimization-based approaches that increasingly accounted for future casualty arrivals and uncertainty. • A constrained Markov Decision Process (MDP) model that represented the dynamic nature of battlefield evacuation and incorporated equity considerations into dispatch decisions. The models simulated casualty arrivals, casualty severity, MEDEVAC availability, travel times, medical treatment facility capacity, and operational constraints within a battlefield environment. Extensive numerical experiments were conducted under varying casualty rates, resource levels, and operational conditions.
What did the Research Find? The study found that optimization-based dispatching approaches consistently outperformed traditional rule-based policies. Models that anticipated future casualty arrivals and uncertainty achieved higher survival rates, improved resource utilization, and better overall system performance than nearest-available dispatch approaches. Key findings included: • Anticipatory planning significantly improved casualty survival outcomes compared with reactive dispatching.

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- Two-stage stochastic optimization and multi-step optimization policies demonstrated the strongest performance across a wide range of battlefield conditions.
- Shorter decision-making intervals improved responsiveness and survival outcomes.
- Explicitly considering uncertainty in future casualty arrivals improved allocation of scarce evacuation resources.
- Incorporating equity considerations through the MDP framework supported more balanced access to evacuation resources across regions, casualty groups, and operational scenarios

What does this Research Mean?

The project demonstrates the value of advanced analytics, optimization, and artificial intelligence methods for military medical evacuation planning. By anticipating future demands and incorporating fairness considerations, decision-support systems can improve casualty survival, enhance resource allocation, and strengthen operational effectiveness during large-scale casualty events. The findings provide a foundation for future development of decision-support tools that could assist the Canadian Armed Forces and allied organizations in managing complex medical evacuation operations under uncertain and high-pressure conditions

Sources

Davood Pirayesh Neghab, Aliaa Alnaggar, and Mucahit Cevik. Battlefield Evacuation Optimization during a Mass Casualty Incident Project Report. Toronto Metropolitan University, November 2025. Funded through the Joint Federal Research Funding Program for Military Personnel and Veterans

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