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QUANTIFYING MEDICAL RISK TO IMPROVE MEDICAL SYSTEM DESIGN ON A LONG DURATION LUNAR MISSION: A DEMONSTRATION OF NASA'S IMPACT TRADESPACE ANALYSIS TOOL

Abstract

BACKGROUND NASA's human exploration spaceflight missions to the Moon and Mars present unprecedented challenges for in-mission medical care. A greater distance from Earth will mean increased mission durations, communication delays, limited resupply opportunities, and constraints on the evacuation of ill or injured crew. Mass, volume, and power will be limited while higher demands will be placed on the crews to manage medical events. NASA's Moon to Mars exploration strategy outlines increasingly complex Artemis missions both in terms of duration and operations. In these deep space missions, it is important to quantitatively estimate the human system risk attributable to medical conditions and use these estimates to advance medical system design.

METHODS IMPACT (Informing Mission Planning via Analysis of Complex Tradespaces) is a probabilistic risk assessment (PRA) and tradespace analysis tool developed by NASA to advance exploration mission medical system design. IMPACT v1.0 includes a novel evidence library baselined to exploration environments; an expanded list of 119 medical conditions; an increase in the number of medical resources and the flexibility of their use; and the ability for rapid and iterative analysis. Medical system risk estimates include loss of crew life, consideration of the need for return to definitive care (medical evacuation), and an estimate of crew time affected due to medical conditions. A notional long duration lunar orbit and lunar surface design reference mission (DRM) was chosen with a 4-astronaut crew to mimic a foundational exploration Artemis mission. The DRM profile includes outbound transit on Orion, Gateway space station rendezvous in lunar orbit, 6 months on the Lunar surface with extravehicular activity (EVA), return rendezvous with Gateway, and transit back to Earth.

RESULTS/DISCUSSION: Overall, IMPACT successfully quantified medical risk and derived an optimal medical system to support crew on a long duration lunar mission. In this DRM, the calculated loss of crew life from a medical event was 0.008 events per mission, risk of potential need for evacuation was 0.30 events per mission, and cumulative crew time affected by medical conditions was 103 days. The medical conditions that most contributed to medical risk were decompression sickness, trauma, and respiratory failure. The conditions with the largest effects on crew performance included musculoskeletal injuries and lunar dust exposure. The IMPACT-generated medical system included resources that target the most common and highest risk conditions and performed as expected. This demonstrates the value of the IMPACT tool in medical system design for human exploration spaceflight missions.