# NASA OFFICE OF THE CHIEF HEALTH AND MEDICAL OFFICER APPROACH TO CREW SURVIVABILITY: AN ANALYSIS FOR FUTURE SPACEFLIGHT MISSIONS

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## ABSTRACT

With the increasingly complex future of spaceflight missions, thorough discussions concerning crew rescue and evacuation options are being held to properly form better in-flight decisions. Factors that pose the largest concern to future spaceflight missions are the prolonged duration and further distance from the Earth. These factors make the likelihood of immediate crew evacuation an unviable option, so it is extremely valuable to consider potential survival scenarios and their mitigations to improve in-flight decisions on vehicle capabilities, mission supplies, crew make-up, and rescue options. In survival situations of varying complexities and severity, it is ideal to limit food and water intake, cancel extravehicular activities (EVA), reduce daily activity, and reduce oxygen consumption/carbon dioxide production until crew rescue can occur. Human physiological factors should be fully understood in order to outline the extent of these limitations while keeping the crew healthy.

During a state of emergency, the following of items should be considered:

1. Decreasing oxygen consumption and carbon dioxide output.
    - This can be done by lowering the respiratory quotient (RQ). RQ is defined by the volume of carbon dioxide produce over the volume of oxygen consumed during respiration. This value typically ranges from 0.7 to 1 and can indicate what macromolecule is being metabolized. For instance, a RQ of 1 indicates that carbohydrates are being metabolized, while an RQ of 0.7 indicates fat metabolism. It is indicated that purposefully sending the body into ketosis, the metabolism of fats instead of carbohydrates, will lower the RQ and oxygen consumption. In order to promote ketosis, high fat diets will be implemented while strictly limiting carbohydrate consumptions.
2. Decreasing food and water intake.
    - In moderate scenarios, calories should be limited to 1800 calories/day and in severe scenarios calories should be limited to 600 calories/day. These values are recommended due to the limited physical activity. The severe scenarios value allows a potential 10% loss of body weight in 52 days. Studies have found that 10% of body loss in weight has no effect on cognitive performance. Mild to moderate dehydration can result in physiological and psychological effects resulting in fatigue, memory loss, medical complications, and lethargy.
3. Environmental parameters.
    - Environment parameters have effects on metabolic rates. If temperature is increased, the metabolic rate will increase rapidly then drop while if the temperature is reduced, the metabolic rate will increase.
4. Consideration of illness
    - Crewmembers experiencing illnesses will require personalized protocols. Illnesses can create impacts on oxygen consumption, carbon dioxide production, increased hydrational needs, increased nutritional needs, and different temperature tolerances.