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Preventing and Controlling Infections during Extended Human Spaceflight

Kevin Zheng*

Department of Associate Managing Editor, Heriot Watt University, Edinburgh, United Kingdom,

***Corresponding author:** Kevin Zheng, Department of Associate Managing Editor, Heriot Watt University, Edinburgh, United Kingdom; E-mail: zheng.k31@gamil.com

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Abstract

There can be several health issues, including skin issues, during both short- and long-duration spaceflight. The skin of astronauts is erythematous, blistering, itchy, dry, sensitive, and thinning both in space and when they return to Earth. Infections, abrasions, lacerations, delayed wound healing, and accelerated skin aging is some more prevalent skin issues. Human skin is an ecosystem made up of a variety of habitats for bacteria, fungi and viruses known as the microbiome, which not only exhibits a strong preference for the skin's distinct environment but also acts as a person's extremely individual microbial fingerprint. These bacteria connected with human skin significantly contribute to the microbial ecosystems that live in the space environment's confined settings. The human skin microbiome, on the other hand, is also susceptible to change during spaceflight, which might result in skin infections or a flare-up of skin illnesses. It is a challenging endeavor to launch humans into space, both technologically and medically. Engineers and scientists make every effort to recognize and reduce any hazards that may arise. One such worry arises from the possibility of the spread of a contagious disease within a spaceship, which is exacerbated by numerous elements particular to an extraterrestrial environment. Astronauts' immune systems may be weakened by several conditions related to the space environment, including an increase in microbial growth and microflora exchange, altered virulence, and reduced antibiotic efficacy. To ensure a secure and effective space of living, a satisfactory solution to the aforementioned issues must be found. Long-term human travel to another planet or asteroid will provide special problems for reducing the danger of illness.

Keywords: Erythematous, Extraterrestrial, Antibiotic efficacy, Contagious disease.

Introduction

A space traveler’s capacity to avoid acquiring infectious agents or reactivating latent infections may be impacted by how microgravity, radiation, and stress affect human immunoregulatory responses. Furthermore, prospective microbial pathogens pathogenicity, growth dynamics, and biofilm formation are impacted by microgravity. These interactions take place in a small area while in microgravity, which presents many opportunities for significant environmental microbial contamination. Aerosolized, microbe containing particle persistence is another factor. Any mission that requires extended human spaceflight must be properly prepared to reduce risks and increase the chance of success. A lengthy stay in microgravity has a variety of physiological impacts on the human body, including bone density loss, muscle atrophy, and head ward fluid shift, which have all been reported in astronauts on the International Space Station (ISS). Missions to the Moon and Mars are now scheduled for the late 2020’s and 2030’s thanks to the recent formation of an increasing number of government and private space agencies. These next missions might take 30 months to complete and need landing on a planet with absolutely no infrastructure for medical monitoring or treatments. However, there are very few studies on the physiological effects of long-term missions. The study of molecular changes in the human body brought on by exposure to spaceflight stressors like microgravity, radiation, noise, a restricted diet, and fewer opportunities for physical work is necessary as a result of these long duration missions and humans being exposed to more conditions unique to spaceflight. The NASA Twins Study made it possible to analyze how long duration space travel affected human biology and immune system cellular differences. The effects of spaceflight on cell free DNA, however, have never been the subject of research (cf DNA).

Description

The US National Aeronautics and Space Administration (NASA) are actively planning for sustained human spaceflight. It is predicted that a voyage to and from Mars will take a minimum of 520 days, the crew will be 360 million kilometers from earth, there will be a 20 minute one way communication delay from this distance, and there may be no means to return to earth until the mission is done. The issue of avoiding and managing illness is unique to space flight. The complexity of this task is increased by the physiological effects of microgravity on people, exposure to solar and cosmic radiation, the stress of being confined, and the wide range of modifications seen in microorganisms in this unusual environment. It cannot yet be conclusively stated that a genuine clinical risk associated with immunological deregulation exists for exploration class spaceflight, according to Crucian and Sams. However, prospective microbial pathogens exhibit increased virulence factor expression, more quickly enter the log phase of development in a liquid medium, and may promote biofilm formation in microgravity. While in space, the immune system of humans is dysregulated, which increases the risk of infection, including the reactivation of herpesviruses. Staphylococcus aureus, along with Enterobacteriaceae, is more prevalent on the skin and in the upper airways, and the anaerobic colonic flora is also decreased with a corresponding rise in aerobic bacteria including Pseudomonas and Staphylococcus aureus. Within the walls of a confinement vessel like the International Space Station, several circumstances are favorable to the propagation of illness. Microbes survive in free-floating condensate, and transmission of microbial flora including some multidrug-resistant pathogens among astronauts has been demonstrated. Symptom based medical management of conditions may be carried out by people who may not have medical or nursing degrees, and they must consult with earthbound doctors at mission control. According to post flight medical debriefs, there were 29 infectious disease incidents among the approximately 742 crew members who have flown 106 space shuttle flights, including fever/chills, fungal infection, flu like illness, urinary tract infection, aphthous stomatitis, viral gastroenteritis, subcutaneous skin infection, and other viral diseases. A spacecraft or space station's interior atmosphere may become highly polluted with germs, and free floating condensate has been shown to contain a variety of bacteria, fungus, and even protozoa. The aerobiology of aerosols produced during speaking, coughing, and sneezing is impacted by microgravity. Until they are inhaled, ingested, come into contact with another absorbent surface, or are preferably quickly removed by an air filtration system, particles stay in the atmosphere. The risk of spreading germs like S. aureus as well as viruses like the flu from one person to another is impacted by the presence of these aerosols. High Efficiency Particulate Air (HEPA) filter and humidity controls are ideal for filtering and maintaining breathing air within a spaceship or habitat. But the utilization of such an air-handling system is now impractical due to the energy demands of the current filters. If technically possible, the danger of airborne microorganisms entering the containment vessel after docking should be reduced by taking into account positive or neutral pressure inside the containment vessel. In the containment vessel, it should also be taken into account that the pressure in the bathroom should be lower or equal to that in the living areas. To reduce the growth of biofilms, the water storage and delivery system should be built from non-corrosive materials with less organic carbon. To further reduce microbial growth in the water system, anti biofouling coatings and materials need to be developed.

Naturally, these substances must not expose the astronauts to any potential toxicity. The current method of disinfection for potable water, catalytic oxidation, should be used instead of pasteurization. Point of use submicron filters should be included in redundancy for further protection against watery microorganisms. Potable water outlets that are activated by foot pedals will reduce the possibility of pathogen transfer and contact contamination. Surfaces within the spaceship should be coated with a nonleaching, nonporous antimicrobial substance as long as the astronauts are not exposed to it for an extended time by touch or aerosolization.

Conclusion

It is important to analyze additional design factors, such as waste processing and controls for temperature and humidity. As an alternative, environmental surfaces might be made less microbially contaminated by using a low power portable UV light device that has been created and demonstrated to be successful.