Microbial Monitoring and the Risk of Infectious Disease aboard the International Space Station

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ABSTRACT

The International Space Station (ISS) is a semi-closed habitat in low Earth orbit with environmental conditions provided by an advanced life support system that controls temperature and recycles air and most of the potable water. The crew’s activities, such as eating, sleeping, hygiene, and laboratory research, are performed in relatively close proximity. Research in the laboratory includes a myriad of experiments, including those with rodents, plants, and pathogenic microorganisms. Despite these conditions, in-flight monitoring of ISS indicates that the microbial diversity is similar to homes on earth. Accordingly, the crew is generally very healthy, however infectious disease does occur and potential routes of infection by obligate and opportunistic pathogens cannot be completely prevented. Determining the extent of this risk is further complicated, as microorganisms can alter their characteristics in response to spaceflight culture, as exemplified by the increase in virulence of the enteric pathogen Salmonella enterica Typhimurium during spaceflight compared to otherwise identical cultures grown on Earth. Taken together, these factors suggest a need for continued microbiological monitoring and research to understand and mitigate the risk of infectious disease during long duration missions.
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**THE RISK OF ASTRONAUT INFECTION**

**Positives**
- Preflight medical exams and medical consult throughout a mission
- Preflight crew quarantine
- Stringent microbiological monitoring of spacecraft and its cargo

**Negatives**
- Small enclosed environment with recycled air/water
- Limited medical diagnostics and treatment on board
- Limited environmental remediation capabilities
- Dysfunctional aspects of the crew immune system
- Unique alterations of microbial characteristics, including virulence

**ENHANCED VIRULENCE IN RESPONSE TO SPACEFLIGHT CULTURE**

Multiple experiments over the past 50 years have indicated unique microbial responses when microorganisms are cultured during spaceflight, including changes in growth kinetics, antibiotic resistance, and biofilm formation.

The MICROBE Experiment (PI: Cheryl Nickerson, Arizona State University) investigated the response of the enteric pathogen *Salmonella enterica* serovar Typhimurium cultured during spaceflight compared to otherwise identical *S. Typhimurium* cultured on Earth (Wilson 2007).
- Spaceflight grown *S. Typhimurium* grown in LB broth killed mice faster and killed mice at lower doses than identical bacterial cultures grown on the ground. These findings were reproduced one year later on a separate spaceflight mission (Wilson 2008).
- S. Typhimurium grown in the spaceflight environment displayed an extracellular material not seen in ground controls.

**REFERENCES**


**MONITORING SUMMARY**

- Current vehicle design and operational activities generally maintain microorganisms at low levels.
- The microorganisms isolated from ISS are common environmental organisms similar to those found in terrestrial homes.
- Contamination events do occur, often from uncontrolled water sources, such as condensate formation and crew hygiene activities.
- Potable water is maintained below 50 CFU/ml. Bacterial isolates are primarily from the genera *Ralstonia*, *Burkholderia*, and *Sphingomonas*.