

Perspective

Advances in Space Medicine Applied to Pandemics on Earth

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Preparation and planning are critical when facing an epidemic or pandemic. Timely solutions must be incorporated in addition to existing guidelines in the case of a fast-spreading epidemic. Advances in space health have been driven by the need to preserve human health in an austere environment, in which medical assistance or resupply from the ground is not possible. This paper speculates on the similarities between human spaceflight and epidemics, extended to pandemics, identifying implementable solutions for immediate use by healthcare personnel and healthcare systems. We believe aerospace medical research can be seen as a resource to improve terrestrial medical care and the management of patients on Earth.

1. Introduction

In healthcare and medical technology, space is considered to be at the centre of medical innovation, as the underlying research-development chain addresses implementation of medical assistance and healthcare under extreme environment conditions [1]. Advances achieved in space life science research are being translated to healthcare on Earth, especially considering healthcare delivery in remote locations or in natural disasters. This paper aims to raise awareness of some similarities between the healthcare used in crewed space missions and terrestrial healthcare to identify potential approaches used in space that could become solutions to challenges seen in terrestrial epidemics and pandemics.

2. Similarities between Human Spaceflight and Pandemics

During the public health emergency of coronavirus, namely the COVID-19 pandemic, government-led containment measures to limit person-to-person contact included social distancing, isolation, and quarantine. During quarantine, people are asked to self-monitor their vital signs and observe for symptoms that could be disease-related, while also limiting movement and remaining at

home to reduce risk of contaminating others and further disease spread [2]. People with a positive disease diagnosis are subsequently separated from those thought not to be contaminated, thereby undergoing a period of isolation. Confinement comes with isolation, as individuals with a positive diagnosis and worsening symptoms are placed in hospital or an emergency room, organized by the medical system to provide the appropriate care needed to treat the disease. In this scenario, positive patients are not isolated from the medical team, who may or may not acquire the disease during patient care.

Astronauts on the International Space Station (ISS) live and work in an isolated and confined environment, raising similarities with some aspects encountered in epidemic or pandemic. Although isolated, astronauts maintain continuous communication with the ground control of Mission Support, who provide in-flight guidance and assistance at any time during the mission. In general terms, astronauts in space live under stressful conditions and in a hostile environment, while being required to maintain high-level performance throughout a mission. Similar findings have been noted among crewmembers in a ground-based simulation of space missions where participants are selected with a less stringent requirement for physical and mental performance [3].

TABLE 1: Implementable solutions currently used in the space sector.

Challenges	Object	Time	Cost	Implementable solutions
Lack of man-made/artificial supplies	Manufacturing	Short term	Low cost	3D printing surgical tools and supplies
Lack of trained health personnel	Organization	Short to long term	Low cost	Recruit social service workforce
Lack of sleep	Organization	Short to long term	Medium to high cost	Adopt sleep countermeasures tested on the ISS (rest schedules, pharmacologic interventions, and lighting strategies) [5]
Lack of personal protective equipment	Production	Medium to long term	Medium to high cost	Use materials that can be recycled with available tools
Lack of hygiene	Research and development	Short to medium term	Medium cost	Adopt hygiene countermeasures used on the ISS [9]
Lack of food supplies	Organization	Short term	Medium cost	(i) Use dehydrated food, such as that used on the ISS or in ground-based space missions (ii) Ration food
(Social) mental health, public panic	Organization	Medium term	Medium cost	(i) Use available digital health solutions, such as eHealth and mHealth, and contactless digital solutions [6] (ii) Provide/establish a telephone support line (like that connecting astronauts to flight surgeons on the ground)
Social cohesion	Organization	Medium term	Medium cost	(i) Educate people to develop coping mechanisms (ii) Promote positive attitude, self-esteem, and self-worth (iii) Promote social identity using cultural and social symbols or through communication channels
Lack of pharmaceutical drugs and vaccines	Research, development, and production	Medium to long term	Medium to high cost	(i) Testing of epidemic/pandemic drugs in space. For example, ESA tested the remdesivir-based medicament against COVID-19 in microgravity [10] (ii) Leveraging on adaptative immunity during spaceflight [11–13] (iii) Developing and producing drugs in space

3. Implementable Solutions

On-going missions on board the ISS are not completely self-sustainable, as astronauts benefit from periodic replenishment of provisions and continuous communications with the ground control. On the other hand, planning for future human missions to the Moon and Mars builds on the basis of having a fully self-sustainable mission concept, especially for medical aspects, where the crew will need to be autonomous or Earth-independent.

The necessity for fully independent sustainability, management of crises, and health safety could be transferred or integrated into the existing actions and strategies developed to mitigate epidemics and pandemics on Earth. Advances

in medical care for space missions are designed to address health issues under extreme conditions, while respecting international regulations, norms, and laws.

Strategies used for preparing and planning human space missions may help in resolving the practical challenges reported on how to respond to an epidemic or pandemic on Earth [4]. Published literature speculates on the lack of readily available comprehensive guidelines and need to have international regulations that are compatible with the working and living environments in which epidemics and pandemics may occur [4].

The hazards to human life experienced during a spaceflight have similarities to those seen under conditions of epidemic or pandemic, when looking at human factors and

medical challenges. However, practical aspects of space medicine may be applied to global health on Earth with limitations. Developments from space medicine build on research studies performed on the astronaut corps over a series of space missions; however, there is no clear evidence that such advances may translate well to a larger population. The internal dynamics within the population may diminish the impact of any preventive or containing measure of an epidemic or pandemic. The dynamics of analogue astronauts during ground-based space missions can have parallels with small groups in society, such as families, but may not necessarily be representative of the dynamics found in a large-scale population.

Nonetheless, advances in knowledge developed for astronaut care in space may assist healthcare personnel and managers, as well as populations on Earth, as timely solutions to the problems presented by epidemics and pandemics, especially when containment measures or preparations are more stringent (see Table 1).

Space countermeasures, defined as actions or measures used to counteract specific hazards to human health in a crewed space mission, can be considered translational for application in conditions of epidemic or pandemic on Earth. A good example would be countermeasures applied to improve astronaut sleep patterns, such as medication and maintenance of sleep-wake cycle hours in a day. Sleep countermeasures used by astronauts may be adopted by healthcare personnel to reduce the extent of discomfort negatively impacting on human performance during epidemics or pandemics [5].

In addition, the lack of trained healthcare personnel may be overcome by recruiting the workforce from the area of social services. Telemedicine applied at the ISS has provided some inputs for the provision of healthcare in rural and remote areas of the globe [6, 7].

Containing measures, applied to restrict the spread of epidemics and pandemics, may also limit the provision of food and resources. Technology, such as 3D printing, may help overcoming such limitations. Indeed, the knowledge acquired in the use of 3D printing in spaceflights can be easily transferred to terrestrial healthcare, being used for producing dental, medical, or surgical tools, and pharmaceutical products [8].

In conclusion, the knowledge acquired during space missions can be applied as the basis for a better understanding and more effective management of similar situations on Earth, such as the lockdown, social distancing, and isolation that have currently been experienced by society worldwide, as a consequence of the COVID-19 pandemic. This paper raises awareness of the importance of advances in space medicine in relation to epidemics and pandemics only. The content builds on the professional experiences of the authors in the field of space medicine and aerospace human factors.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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