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Is Personalizing Space Medicine, Truly the Future of Space Medicine

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ABSTRACT

Space is a mystery, anything can happen when you are up in space. Astronauts have to be prepared when they travel outside the earth's atmosphere. When going into space many things can go wrong. However, the biggest factor that can go wrong is the astronaut's health. Getting sick in space could be fatal as astronauts have very few options for medication and such. Remember that when going to space many factors make astronauts sick. Over the years space medicine has challenged the boundaries from when it first started. As we move forward, it will become a bigger challenge as we dream bigger to one day colonize Mars, hence we need to improve space medicine. In this essay I have prepared to explain what I believe could be the future, in a way that ensures the astronauts we send into space are safe, hence the idea of personalized space medicine.

Introduction

You are unique. From your eyes to your personality, there is more to a person than just that, more things that make you unique. Your health, risk for disease, and the ways you respond to medicines. Medicines that work well for some people may not help you at all, they could even cause more problems for you. Just imagine if there was a way for treatments and preventive care that could be designed just for you. This idea of treatment is called personalized medicine. Personalized medicine is the idea that medicine can be used by studying an individual's genetic profile to help guide decisions made regarding the prevention, diagnosis, and treatment of disease. In more simple terms personalized medicine is the tailoring of medical treatment to individual characteristics. Personalized medicine or PM can create the best response and highest safety margin to ensure better patient care. This happens by enabling each patient to receive earlier diagnoses, risk assessments, and optimal treatments, PM holds promise for improving health care while also lowering costs. Based on what I spoke about, my topic leans toward the space field, specifically space medicine. I chose space medicine as it is the future of medicine, as technology advances, ideas, for example, space travel is becoming more and more popular, and the idea to live on Mars is an idea that could happen in the next decade or so. Picking this topic meant, picking the future. In today's world more than 49% of Americans want to travel to space, says Jacqueline DeMarco. That’s more than 138 million people who want to go to space. Not only people but companies want to colonize Mars, Mars will be colonized by humans by the year 2050, says Neil Martin, a UNSW expert. As this is the future, space medicine can help everyone. Over the years technology has improved significantly, ever since the first man landed on the moon back in 1969, to now 2022. Not only has the technology helped those in space, but on earth as well. According to NASA archives of the mission, the astronauts flew with two medical kits that included all kinds of uppers, downers, and even pills. NASA explained in a 1969 news release about the mission. "The medical kit contains three motion sickness injectors, three pain suppression injectors, one two-ounce bottle first aid ointment, two one-ounce bottle eye drops, three nasal sprays, two compress bandages, 12 adhesive bandages, one oral thermometer, and four spare crew biomedical harnesses.", this may have been helpful at the time, but as we move on in life, technology also moves on. We need better healthcare systems if we truly want to explore the vast vacuum of space. Not only will astronauts benefit, but the whole of human society also, as

it shows progress. My goal today is to address the issues facing humans in space and to explore if personalizing medicine is truly what can push space medicine into the future.

The Effects of Space on the Human Body

Journeying into space is like journeying into the unknown, anything can happen at any given time, and the moment astronauts enter space, they are at risk. "NASA is researching risks for Mars missions which are grouped into five human spaceflight hazards related to the stressors they place on the body. These can be summarized with the acronym "RIDGE," short for Space Radiation, Isolation and Confinement, Distance from Earth, Gravity fields, and Hostile/Closed Environments". The human body is a fragile thing, and going into space can sometimes damage the body, and in most cases even can permanently damage the body for good. Skin radiation is one of the biggest concerns when going to space. The most dangerous type of radiation is called ionizing radiation when it enters the body, electrons are stripped from their atoms thus damaging DNA. When DNA damage occurs, one or both strands of its structure break apart. When one strand breaks, the other strand can be used as a template for repair. However, when both strands break, repair mistakes are more likely, and the incorrect DNA sequence can lead to potentially harmful mutations. This can oftentimes lead to skin cancer, and cardiovascular problems, it can damage the heart, harden and narrow arteries, and/or eliminate some of the cells in the linings of the blood vessels. This type of radiation exposure can also cause neurogenesis, which is the process of generating new cells in the brain. Medication can be given to help prevent these hazards, but as stated before each person is unique, and has a unique body system, so what if the medications that are taken, doesn't help all the astronauts.

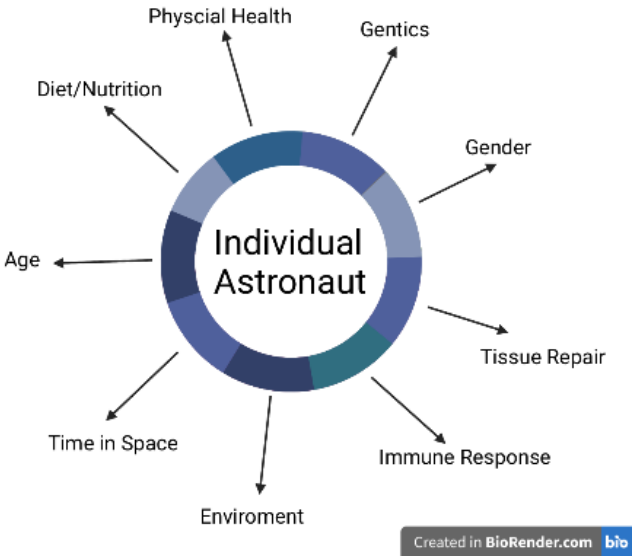

Figure 1. Above in the diagram, it shows the "effects" that go into making medicine for any space travel. When going into space everything is considered, from age to diet all the way to the actual environment of space. Created and copyrighted by Shifali Maheshguru

As seen in the diagram above when going into space there are so many risks that are considered. Age is important because as an astronaut gets older, the less of an immune system they have, which causes them to

be more likely to become sick and/or get health problems. Diet and nutrition matter as the astronauts must eat healthy while in space, otherwise, they will get out of shape, and in space that's a very bad and concerning thing. How long the astronauts are up there also matters as some diseases and sicknesses might not show early on. Tissue repairs matter as without it, we wouldn't be able to maintain the integrity and function of the body in response to a variety of injuries and diseases. The environment is probably what most astronauts' medicine is focused on as there is space radiation and bacteria that could harm the astronauts. Now I ask the question again what if the medications that are taken in space, doesn't help all the astronauts.

How Technology Has Evolved alongside Space Medicine

Technology is something that is always improving, new ideas are being made and tested every day. In this world technology helps us more than anything, it makes sure we are safe, we are healthy, and much more. This can also be said for space medicine, to see the future, we must first see the past, what space medicine was like in the past century. Around the time of the end of World War ll and the beginning of the Cold War, development of rockets was happening, between the former Soviet Union and the USA. Research on aerospace medicine, the foundation required to realize human spaceflight, began in the 1950s, due to this idea to get a man on the moon. In April of 1961, the first human spaceflight was achieved with the flight of Yuri Gagarin. Before the launch, some claimed that long exposure to a microgravity environment would be fatal, however, the mission was a success. After said event happened, NASA's Gemini Program was undertaken with the intent to extend the number of days of human flight, and many medical measurements were taken during the Gemini and Apollo Programs. During 1973 and 1974 NASA had three human flights launched. During these launches, experiments were carried out to investigate how space would affect the human body, which helped lead to a more understanding of the medical issues involved in spaceflight. In 1981, NASA successfully flew the Space Shuttle for the first time, which allowed seven astronauts to stay in space for two weeks. Over the decade technology has developed and diagnostic equipment has improved, which can assist with the selection of crew members. Dr. Weerts said that we "'are more able to pick up certain medical conditions now, for example, cardiovascular risk and renal stones. In the case of renal stones, we want to avoid putting people with a tendency to produce kidney stones at risk of this occurring in orbit as well as diagnosing those who already have stones'". The medical base has increased, and humans have over time gained more knowledge, which helped create better technology, furthering space medicine, this includes per-provided medicine, drugs, and more. Not only that but with the increased amount of medical knowledge astronauts can be better assisted in their rehabilitation once back on Earth. Why does this matter you ask? What does this have to do with personalized medicine? Personalized medicine is a by-product of technological evolution. At its core, personalized medicine uses information about a person's genetic makeup to tailor strategies for the detection, treatment, or prevention of disease. This can include genetic screening tests to identify susceptibility to disease or more precisely pinpoint existing conditions. Then advances in medicine and drugs, so that they are personalized, are directly related to the evolution of technology.

What is Personalizing Space Medicine

Personalizing space medicine, that's the topic of this paper. How do all of these components help prove whether or not personalizing space medicine is the future of space medicine? We're about to find out. Space as said many times is dangerous and if you are not fully prepared, it could be catastrophic. In a study, it was found that humans could live in space for a year or more, but the space environment affects individuals differently, and not everyone can safely stay in space for long periods. Space medicine began with the question of whether or not humans can survive in space, and today, the focus is on improving methods of managing astronaut's health.

Personalizing medicine can directly relate to this. Early on we talked about how space affects a human body mentally and physically, but there's more that can be taken into consideration such as gender, age, immune response, nutrition, etc. If we don't take into consideration any of this, medication given to astronauts could be fatal for some, as it would not help in space. The idea of personalized medicine can help make sure that each individual has the proper medication and drugs given for them to have the best chance to thrive in space. Personalized medicine targets specific conditions and disease in each person giving them their best chance at survival here on earth. Now apply that to someone who does space travel. An astronaut might have a better chance of being healthy.

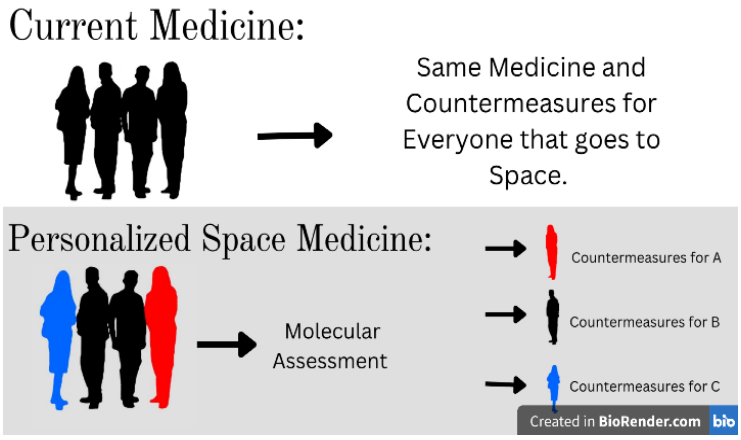

Figure 2. In the figure above there are two separate parts displayed, the top image shows space medicine as of the present day. Each astronaut has the same countermeasures and the same medication in every circumstance. This could lead to some astronauts not being affected by the medication and/or getting worse symptoms due to the all-around used medication. The bottom image shows how personalized medicine is used to target each person's unique molecular structure. It helps each person have their best chance with sickness and diseases in space. Created and Copyrighted by Shifali Maheshguru

Personalized Space Medicine Through the Skin Experiment

However, is there actual proof that personalized medicine can help? As of today there are not many tests or experiments done as personalizing space medicine is a fairly new idea, but during my research, I discovered an experiment that was conducted, the skin experiment. During the skin experiment, three studies have provided us with evidence that each person had a different response in space as a result of what happened to their skin.

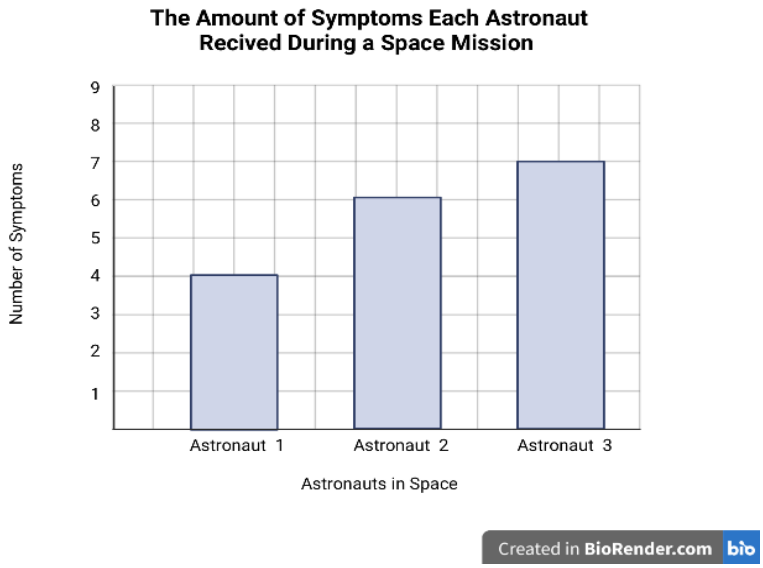

Figure 3. The graph above presents us with a visual of the number of symptoms each astronaut received in the 3 individual tests. The first received 4, the second astronaut received 6, and the last astronaut received 7. They were all given the same countermeasures yet still had different reactions. Created and Copyrighted by Shifali Maheshguru

In the first test subject, we are shown that astronaut 1 experienced 4 different reactions which were delayed epidermal proliferation, decreased hydration, and increased elasticity and transepidermal water loss (TEWL, capacity of the epidermal barrier) during space flight. After this experiment was done there was an initiative taken. Scientists Braun et al. devised a symptom/survey-based report and one based on skin physiological measurements of the same astronauts. In the survey-based study, the astronauts reported similar skin symptoms, with the addition of redness and itchiness. TWEL, (a skin physiology study) showed that skin hydration and skin thickness were quantitatively evaluated among the six subjects with high variability and contradictory results to the earlier study. Recently to add to these two experiments was a study of astronaut microbiomes during long-duration missions that reported diversity between astronaut skin microbiomes. In addition to these observations, a study reported the prolonged (1 year) skin-related problems of one astronaut following mission completion, further highlighting the diversity in skin response. These studies highlight the importance that each person is different and that each person has a unique body composition. This caused them to have different reactions in space. Even if the same medicines/countermeasures were given to both of the astronauts, they both might've had different reactions to the medicine/countermeasure which could have caused an even worse skin reaction, since they both had different reactions without the medicine they probably would have different reactions with medicine. Personalized medicine would specifically target their unique DNA structures causing them to not have different symptoms or have more similar symptoms or even causing the reaction of space on the skin to be much less. That is one overall study/experiment on how personalized medicine would benefit the future. However, I want to add to my claim and reinforce it a little more so I am going to use another serious medical cause that can happen in space, space radiation.

During their voyage in the unknown, astronauts are exposed to space radiation. Space radiation is different from the one here on earth. It's a lot more dangerous and is one of the main health hazards when traveling in space. It has sufficient energy to change or break down DNA molecules which can cause damage to a cell or even kill a cell. This can lead sometimes to health problems ranging from small or short health problems to big and long health problems, but what most people don't know is that radiation levels are mostly individualized because they are based on age, sex, genetics, diet, and much more. Due to this NASA has come

up with a summary of approaches that can help us determine the acceptable levels of radiation risk and their possibilities and long-term missions based on individual factors such as age, sex, genetics, and much more. What all of this shows us is that because everyone is different and everyone has different bodies, the astronauts are susceptible to different amounts of radiation energy. This can cause younger people to be the most radiosensitive. The difference in sex causes women to be more likely to get cancer due to space radiation. Just imagine if each person had the right countermeasures to fit their age, their sex, their genetics, then maybe women or younger people would not be as susceptible to space radiation making them not have long-term diseases like cancer or epidermis.

The Use of Personalized Space Medicine in Immunity

To add more support to my claim, I will explain a theory that scientists believe in. Remember, there aren't many tests done yet to show that personalized space medicine can be a benefit to humans. But scientists do have many concepts and theories in place. One such theory is about the immune system and how to prevent it from getting damaged. Our immune system has a very important job to do, that job is to defend against disease-causing microorganisms. The goal is to keep us healthy. The immune system is a vast and complex interconnected network of many different organs, cells, and proteins that work together to protect the body from illness. However, when traveling in the black abyss that is space many things affect your immune system, even the most subtle changes in the immune system may be linked to the onset of illness. Factors like radiation, microgravity, stress and altered sleep cycle could all cause problems with your immune system. Our immune systems play a central role in our bodies' surveillance of both outer and inner danger signals. Maintenance of the immune system and the response to environmental stressors such as radiation involves a complex interplay between many physiological aspects including the astronaut's nutrition, endocrine regulation, bone marrow activity, exercise, or sleep quality. Dysregulation of the immune system during space flight has been detected by the reactivation and shedding of latent herpesviruses in astronauts on the ISS. After examining the medical records of crew members from a 46 long-duration mission on the ISS, Crucian et al. reported on the incidence of immune-related health adverse events. A striking 83% of crew members experienced a medical event with 46% of crew members reporting a "notable" event. Notable events were defined as prolonged duration, repeated or recurring, and/or unresponsive to treatment. The connection between skin and the immune system made skin rashes the most commonly reported notable event (40%) followed by infectious diseases (29%) and atypical allergies (17%).

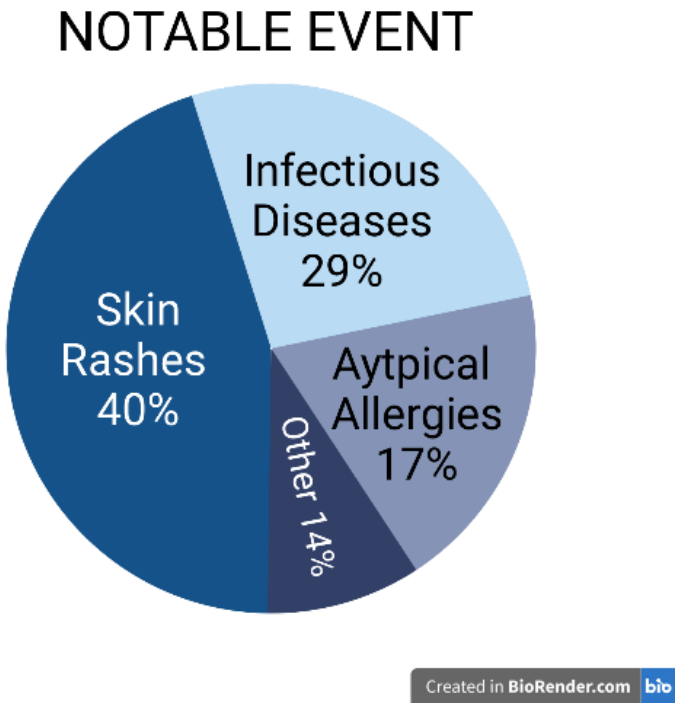

Figure 4. The pie chart shows more clearly the percentages of each type of notable event that the astronauts experienced while in space travel.Created and Copyrighted by Shifali Maheshguru

The most prescribed medication during flight missions is antihistamines used for chronic conditions which persisted longer than 7 days. Characterization of on-orbit rashes manifested as redness with irritation and could be found in a variety of body locations. Whereas these skin rashes and allergic types of events seem to occur at the onset of missions, infectious events tend to develop as the mission progresses from month three onwards. Interestingly, susceptibility to immunological events differed between astronauts with 11 crew members experiencing a single notable event, ten crew members experiencing two notable events, two crew members reporting three notable events, one crew member experiencing four notable events, and one member even experiencing nine notable in-flight events. Therefore, the reasons for interindividual variability in susceptibility to immune events during space flight require further investigation through appropriate longitudinal non-invasive monitoring tools for prevention and early treatment.

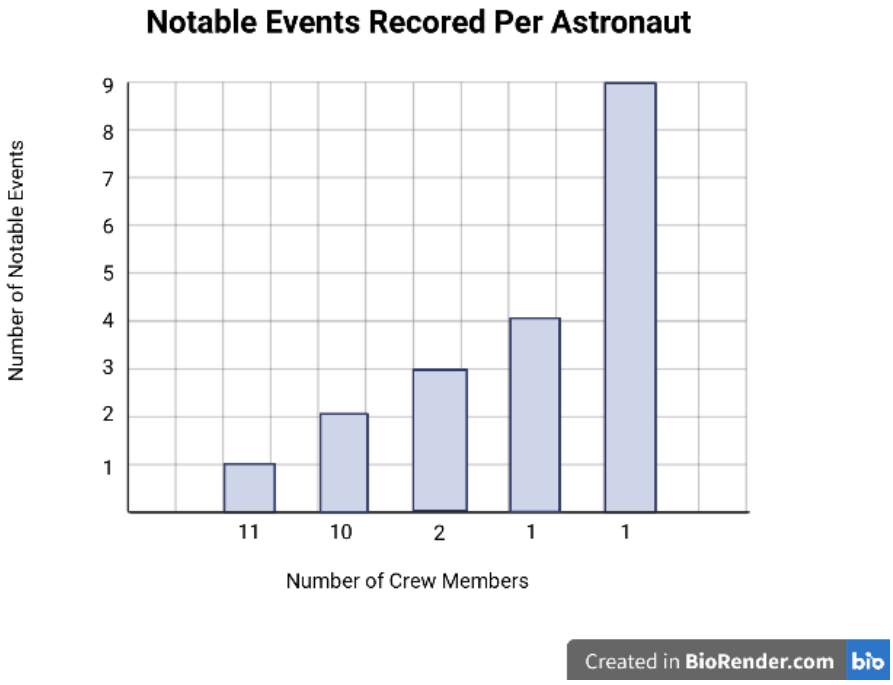

Figure 5. The graph above presents us with the information in the paragraphs before. What this can show us is that each person is different as some astronauts had more reactions than others, and they were also all provided with the same medication, antihistamines. 11 of the crew members reported 1 notable event, 10 crew members reported 2 notable events, 2 crew members reported 3 notable events, 1 crew member reported 4 notable events, and 1 crew member even reported 9 notable events. Created and Copyrighted by Shifali Maheshguru

In recent years, researchers have proposed immune-directed countermeasures to an international panel of experts. They proposed pre-mission screening for immune function, clinical history, herpes virus serology, and vaccination. During the mission, astronauts should be issued personalized recommendations for diet and nutritional supplementation (e.g., glutathione) as well as exercise regimes to maintain the immune system and reduce stressors. “Personalized’ is the word they used to describe what the astronauts needed. Medicine can come in all types of forms, but the form doesn't matter as long as it helps whoever is taking the medication. In this case, individualized medicine can help each astronaut to the best of their ability so they can thrive in space.

Conclusion

Portrayed in the skin experiment, the idea of personalized space medicine is reflected as a positive ideal. Skin is a gateway into your body and if not strong enough, could cause serious damage. Personalized medicine helps target astronauts' specific genomes or diseases, and creates personalized countermeasures for each astronaut. This will cause astronauts' skin to be strong and make sure they have a better experience in space. The immune theory focuses mainly on how personalized medicine can help prevent sickness on board and not only helps astronauts survive but also helps them thrive. However, not only does it incorporate personalized space medicine, but also personalized food and exercise, this will enhance astronauts' health. The question at hand today was “ Is Personalizing Space Medicine Truly the Future of Space Medicine”, now after writing all this, what was proven? It was proven that personalizing medicine is truly the future of space medicine and that it can help reduce and even prevent illnesses and diseases that might occur in space, as well as cure them before they even happen. As of right now, astronauts have to rely on everybody getting the same medicine, which might not

work the same for everyone and it could maybe even harm some astronauts. Personalized medicine targets astronauts on a molecular level, which helps them better because it is tailored to their bodies. Giving them their best chance. I hope that 10 years down the line personalized medicine becomes more than just tests and theories, but an everyday use in space travel. I truly believe that as the human race grows, our medicines must also grow, and that having personalized space medicine in the future is the growth that we need.

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