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ASTROPSYCOLOGY AND CREW RESILIENCE: DEVELOPING A FRAMEWORK FOR MENTAL HEALTH SUPPORT IN LONG-DURATION SPACEFLIGHT

Aya Abdul Karim Al-Taani[1], Mahmoud Mohammad Al-Gharibeh[2], Ali Taani[3]

Psychology Department - Ajman University, Ajman, United Arab Emirates
Email: ayataani22@yahoo.com
Student Counseling and Self-Development Department, Deanship of Student Affairs, Al Qasimia University, Sharjah, United Arab Emirates
Email: malgharibeh@alqasimia.ac.ae
Physics Department, Al-Balqa Applied University, Jordan Email: ali.taani@bau.edu.jo

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Aya Abdul Karim Al-Taani
(ayataani22@yahoo.com)

ABSTRACT

As space agencies and private companies prepare for longer missions beyond Earth, the psychological effects of isolation and distance have be- come an increasing concern. This work investigates psychological challenges faced by astronauts in conditions analogous to isolation asylum, prison and other extreme environments. It addresses constrained sensory input, impaired sleep, social isolation and the mental strain that come with risk and uncertainty. We focus on shared responses such as mood disturbance, sleep difficulties, cognitive fatigue and relationship discord with small crews. A comparative analysis of reports and available data (NASA, ESA, private space companies) to show how contemporary selection and support mechanisms may minimize profound psychological problems such as sleep disorders or mental fatigue. Through a combination of a countermeasures model and NASA's C-O-N-N-E-C-T model we propose a guidance model designed to enhance resilience and team work on long space flights. Although, our work ends with limitations of the current research, but it provides guidelines for future directions in astropsycology, focusing on how observing and pondering space itself could impact individual mental well-being.

KEYWORDS: Space Psychology, Isolation, Astronaut Mental Health, Counseling Models, Resilience, Astropsycology, Overview Effect, Extreme Environments.

1. INTRODUCTION

Human's desire to explore has always pushed us to our physical and mental extremes. As international agencies are aiming for ever greater long duration missions to the moon, Mars, and beyond, psychological health of astronaut is of paramount importance [Kanas & Manzey 2008]. Compared to relatively short-duration missions, the stressors of being in an ICE, the acronym for isolated, confined and extreme, environment for extensive amounts of time - or all of time, unfortunately extend the perfect storm of stressors that affect psychological health, crew dynamics and mission success [Palinkas 2001; He & Jiang 2023; Jain & Jain 2026]. Stressors include, but are not limited to, sensory deprivation, disruption of circadian rhythms, separation from nuclear and extended family, ICE challenges to health, challenges of spacecraft/planet stay, equipment mal- function, invasive missions and other seemingly uncontrollable unknowns [Kanas 2015; Vakoch 2011; Kelly 2017; Williams 2017; Sharp et al. 2025; Taani 2026]. Understanding the psychology of spaceflight is not a foreign concept, early assessments of anecdotes from spaceflight missions indicated mood alterations, interpersonal conflicts and cognitive fatigue [Vakoch 2011; Skotnicky et al. 2025]. However, with projected long-term missions comes a greater need for a substantiated understanding of psychological influence (with projected countermeasures and a guidance/counseling model). Earth-bound analog studies in ICE surroundings, such as those in the Antarctic and underwater, have been useful. They expose how individuals perform and exist in these isolated settings. These studies dispel notions that negative occurrences on missions are confined to an assignment's endpoints. For instance, the "third-quarter phenomenon" is an internationally observed trend. It indicates that people are most likely to suffer reductions in morale or performance at approximately two-thirds of an assignment [Palinkas & Suedfeld 2008; Al-Taani et al. 2025]. Thus, this paper compiles the literature to better understand the psychological impact of spatial isolation and confinement, and are relatively based on spaceflight experiences and analog studies. Second, a critical assessment of stressors present in ICE situations and their derived impacts on psychological health will be presented. Third, a counseling model will be discussed based both on known psychological support options prior and findings that should be promoted to improve resiliency and reduce negative psychological impacts to maximize mission success and provide insight for future long-duration missions.

2. LITERATURE REVIEW

As part of his long-term mission to the International Space Station, astronaut Scott Kelly vividly expressed this feature of isolation: "Being in space is even worse than it looks, there is no place to go out and get fresh air. This quote demonstrates the basic human need for environmental diversity and for the mental toll of lack of variety in space. The loss of basic earthly joys, such as the feeling of soft wind and natural light, becomes the main stress factor, causing a sense of stigmatization or detachment. Kelly explained this particular kind of detachment a bit more [Kelly 2017].

This contrast may intend to highlight the sensory and emotional experiences deprived from those on a planet where natural beauty such as that on Earth disappears. Artificial space environment. The psychological stress of space travel was less obvious but was seen as contributing to astronauts' moods. Astronauts assigned to long duration space missions have a number of psychological stressors, which may prove harmful to the crew and mission success that can be classified as environmental, social and personal stressors. Environmental stressors are: long time exposure, disrupted circadian rhythms due to artificial light and the absence of the natural day-night cycle, and sensory deprivation induced by confinement and the permanent danger of mission fatal disasters. Social stressors are extreme social isolation, separation from life on Earth, limited contact with family and friends, and round the clock exposure to a small number of crew members with personalities different from your own [Tomsia et al. 2024; Smith et al. 2024a,b]. At the individual level, personal psychological stress includes homesickness, boredom, fatigue and high-stakes feeling [Stuster 2010; Cai et al. 2012; Al-Taani & Bani Mustafa 2023; Smith et al. 2023]. Kelly said about this stress: The psychological stress, which is harder to correlate and maybe even more damaging. [Kelly 2017; Taani 2025] The quote is a suggestion that if metrics are not kept in check, the slippery slope of psychological stress could last.

In order to obtain a thorough understanding of the psychosocial repercussions of separation and confinement in space habitats, these narrative accounts are necessary in addition to qualitative psychological evaluations. In order to obtain a thorough understanding of the psychosocial repercussions of separation and confinement in space habitats, these narrative accounts are necessary in addition to qualitative psychological evaluations.

Recent findings [Laham 2023] indicate that including astronauts with prior mental resilience training in mission crews improves collective psychological stability and supports the development of more effective approaches to counseling and stress management during long-duration missions beyond low Earth orbit. The suggested paradigm is affordable, mission enabling, and flexible enough to fit both NASA's Artemis program and similar projects by foreign space agencies. However, [Pagnini 2023] emphasizes the importance of taking psychological aspects into account for prolonged missions, as crew members must deal with isolation, confinement (IC), microgravity, and communication delays. As a result, permission training should prioritize mental health assistance. Numerous psychological impacts have been consistently reported from research conducted in terrestrial ICE analog facilities and microgravity. Anxiety, depression, and irritability are common symptoms of mood disorders [Palinkas 2001]. One of these is sleep deprivation, which is known to lead to increased stress levels and compromised neuro-behavioral performance and is made worse by microgravity and shift work against the natural circadian cycle of crew members [Zhang et al. 2007; Suedfeld 2012]. For example, ISS sleep data show that astronauts reported higher levels of stress and social adaptation, with the mean sleep length lower than the opportunity to sleep [Mohammad 2024]. In ICE prisons, tensions and disputes among inmates are a frequent occurrence. Minor annoyances can escalate into serious interpersonal disputes when one is constantly close to a certain number of coworkers and has few opportunities for social engagement [Lee et al. 2025]. MEN are more affected by declining morale and increased interpersonal conflict, and the "third-quarter phenomenon", the period of time when teams start to experience this phenomenon, is discernible [Palinkas & Suedfeld 2008].

2.1. Psychological Manifestations in Isolated, Confined, and Extreme (ICE) Environments

In investigations of both spaceflight and terrestrial ICE analogs, psychological responses are substantiated and consistently found across the studies. Mood disturbances are the top list with anxiety, depression, and irritability often noted [Palinkas 2001]. Stressors such as sleep deprivation, often complicated by microgravity and intense work schedules, greatly enhance stressors and neuro-behavioral functioning [Suedfeld 2012; Taani 2023a,b]. For example, ISS crew members reported that while time was allocated for sleep, self-determined sleep was much less, and many more crew members noted increased stress and reduced orientation to social tasks [Lee et al. 2025]. ICE environments also create interpersonal stress and conflict as tension between crewmates may be unavoidable with constant proximity to a selected few without available external social intervention available. Thus, any simple disagreement can transform into an arduous interpersonal dynamic [Suedfeld 2012]. In addition, the 'third-quarter phenomenon' is used to describe the expected decline in positivity and the increase in interpersonal tension around the middle of any mission [Palinkas & Suedfeld 2008]. However, in relation to recent findings, such as those made in Skorupa et al. [2024], the timing of when crews begin to feel melancholy can vary over time, however, the most significant finding is that as time in isolation continues, patterns evolve that crews and crewmates must be prepared to address. This dynamic is illustrated in Fig. 1.

This line plot indicates the fluctuation of crew morale over time during a long-duration space mission based on correlations made in isolated and confined environments (ICE). Crew morale is high (Month 1-2) at the beginning due to excitement and acclimatization. A steady decrease occurs over the mid-mission point (Month 3-8) until 'The Third-Quarter Phenomenon' (Month 9) which becomes the lowest point of the mission. This phenomenon will include high levels of irritability and fatigue, as well as interpersonal tension. As missions near completion usually between months 10 and 12 crew morale tends to rise with the prospect of returning home. The timing and intensity of this upswing differ from person to person and mission to mission, reflecting the dynamic nature of psychological adaptation in space. Because of this, flight surgeons and behavioral health teams place a strong emphasis on regular check-ins, flexible coping approaches and steady support rather than strict and fixed protocols. As missions move toward their final stages (typically around months 10 to 12) crew morale often lifts as the return home gets closer. Still, how much and how quickly this boost happens varies from one person and mission to another indicating how differently individuals adjust psychologically in space.

Cognitive performance also varies, with crew members on long duration flights often reporting mental fatigue, reduced concentration and occasional difficulties when making complex decisions [Skorupa et al. 2024]. Emerging research is also exploring how microgravity alters physiology, particularly through the gut, brain axis, and whether these changes affect mood, alertness, or resilience

[Basner et al. 2014].

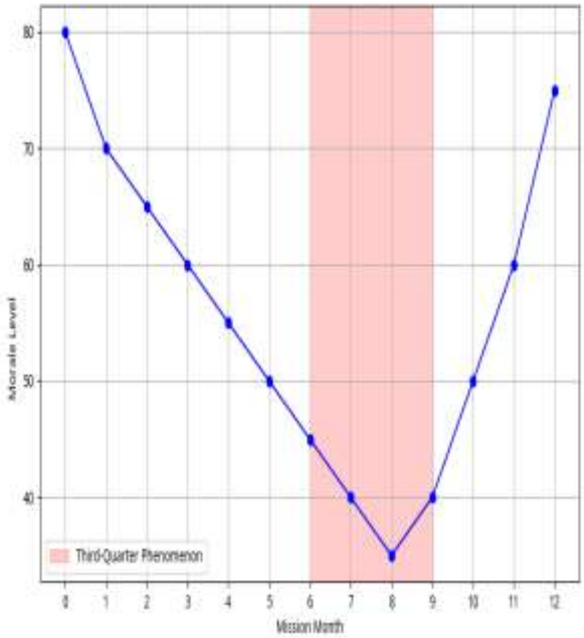

Fig. 1: The crew morale over a 12-month space mission.

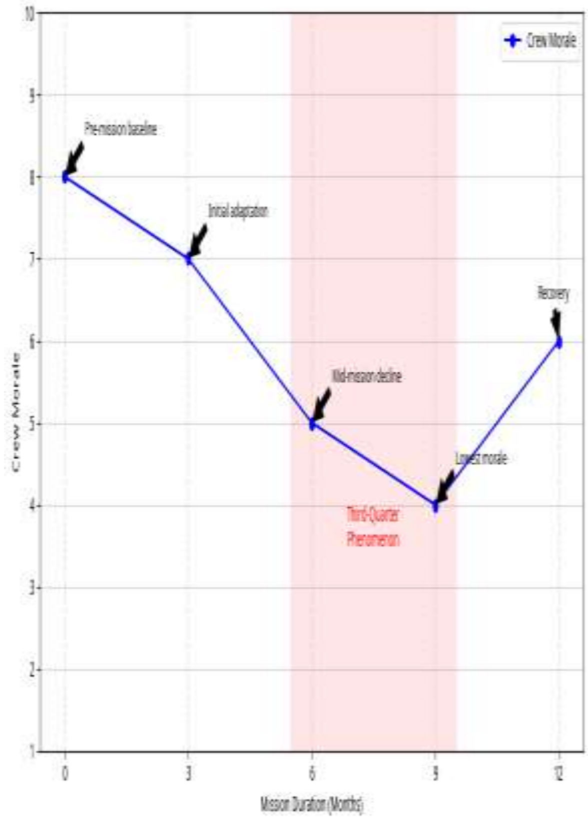

Fig. 2: The same as in Fig. 1, but with different crew morale level.

2.2. Countermeasures and Support Systems

Space agencies have created and put into place a number of solutions to reduce psychological dangers.

Stress management strategies, team building activities, and thorough psychological preparation are all part of pre-mission training [Musson & Helmreich 2005; Tafforin 2015; Gatti et al. 2022]. There are several different types of psychological support system available during operations. These include the provision of personalized care packages, opportunities for communication with family and friends, and frequent private sessions with psychologists [Smith et al. 2022; 2025]. It is also acknowledged that meaningful work and leisure activities are important because they reduce boredom and provide a feeling of purpose [Fleischer et al. 2023]. In addition, cutting-edge technologies such as guided imagery and virtual reality are being investigated to help astronauts cope with feelings of loneliness and preserve a sensory link to Earth [Yin et al. 2023]. The psychological assessment and support methods used by NASA, ESA, SpaceX (Inspiration4), Blue Origin, and Virgin Galactic are compared in Table 1, which highlights the variations in selection, training, in-mission monitoring, and psychological support between commercial and governmental space- flight organizations.

The C-O-N-N-E-C-T model, which highlights community, openness, networking, needs, expeditionary mindset, countermeasures, and training/preparation as essential pillars to preserve psychological well-being in remote situations, is one of the frameworks created by NASA's Human Research Program [8]. These tactics are essential to deal with the particular difficulties astronauts have, as Fig. 2 illustrates. Despite strict selection, astronauts nonetheless encounter psychological stresses, albeit frequently at lower rates than those seen in analog groups or the general public. Fig. 3: Prevalence of psychological problems across populations based on data from NASA webpage.

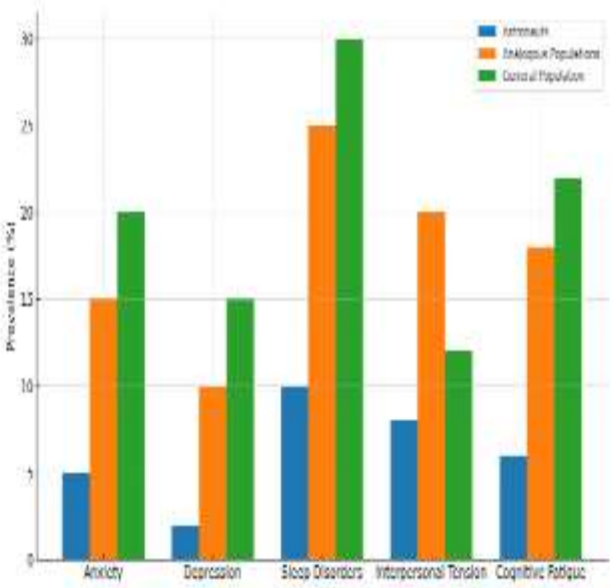

Fig. 3: Prevalence of psychological issues across populations based on the data from NASA webpage.

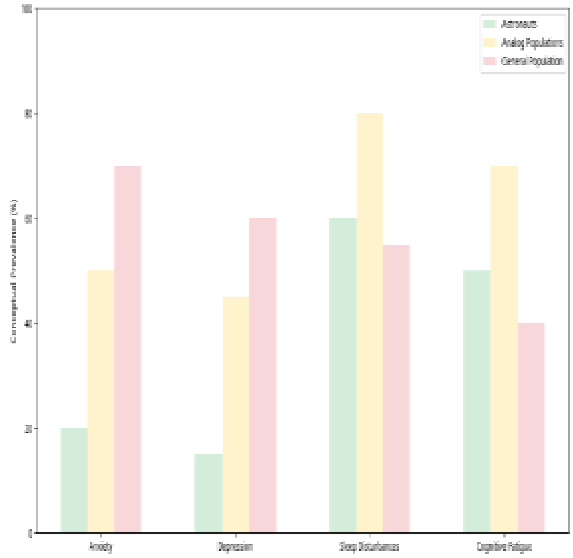

Fig. 4: Prevalence of psychological based on the data from ESA.

The bar chart shows how frequently four key psychological issues (anxiety, depression, sleep disturbances and cognitive fatigue) are reported by astronauts, individuals in space analog environments and the general population. In general, astronauts report lower levels of anxiety and depression compared to the other groups. This trend is often linked to the rigorous selection process thorough pre-mission training and continuous behavioral health support provided in government space programs (e.g. Kanas et al., 2015; Stuster, 2010; Sandal et al., 2018).

Sleep problems and cognitive fatigue are still quite common even among astronaut crews. These issues are largely tied to conditions that are difficult to avoid in orbit such as disrupted circadian rhythms, irregular sleep schedules and high workloads. In comparison, participants in analog environments, who face isolation and confinement without the same level of screening or structured support, generally report higher levels of symptoms across most categories.

These comparisons highlight two key points, the current support systems for astronauts seem to be effective but spaceflight still brings psychological challenges that are not been fully resolved. Research in this area is also somewhat limited mainly because of limited spaceflight participants. In addition, Earth-based analog studies cannot completely replicate the full complexity of actual space missions. Missions beyond low Earth orbit are expected to introduce additional pressures such as increased autonomy, longer communication delays and more extreme environments. Addressing these challenges will likely require more flexible, crew-centered approaches to behavioral health that rely less on Earth-based support.

A second observation from the data is that current trends in space psychology remain consistent. Astronauts generally show lower levels of clinically significant anxiety and depression than analog or population samples. Nevertheless, they still encounter sleep irregularities and cognitive fatigue as these symptoms closely linked to the distinctive demands of the space environment. The analog groups commonly exhibit heightened rates across most indicators reflecting their extended confinement without the benefit of intensive screening or psychological preparation.

This contrast highlights the progress made and the challenges that remain. The sample sizes in spaceflight research are small and methodological differences across analog studies limit any direct comparisons. As missions expands to the Moon and Mars where delays, autonomy and environmental stressors increase, the behavioral health systems will need to become more flexible and more self-sufficient. Enhancing onboard psychological support and developing tools for independent mental health management will be crucial for any successful future deep-space missions.

3. METHODOLOGY

3.1. Methodology: Research Design and Literature Identification:

A convergent mixed methods approach was used to assess the psychological adaptation and the effectiveness of support in the human spaceflight. Quantitative measures such as sleep data, cognitive performance scores and symptom prevalence were combined with qualitative sources including published mission de-briefs, agency reports (NASA and ESA) and post-flight interviews. Commercial missions, in particular Inspiration 4, were also analyzed to examine the adaptation in non-professional crews to expand insights beyond the traditional astronaut selection process.

The literature search followed PRISMA-based procedures. Databases queried included PsycINFO, PubMed and Scopus (2010–2025) with additional grey literature sourced from NASA Technical Reports Server (NTRS) and ESA's Human Research Program archives. The search terms combined MeSH and free-text keywords such as space psychology, isolated confined extreme (ICE) environments, behavioral health countermeasures, third-quarter phenomenon, autonomous crew support, civilian spaceflight and gut-brain axis microgravity. Foundational studies published before 2010 (Palinkas & Suedfeld, 2008) were retained to provide theoretical context. Studies were included if they explicitly addressed psychological or behavioral outcomes while biomedical or engineering focused research was excluded.

3.2. Selection Criteria

Sources examining the psychological or behavioral responses to isolation, confinement or extreme operational environments in spaceflight or closely related terrestrial analogs were considered eligible. This includes included empirical studies, theoretical papers, systematic reviews and meta-analyses. Publications focusing only on the physiological, biomedical or engineering outcomes without clear links to psychological functioning were excluded as well as those lacked sufficient methodological detail to evaluate the reliability of the findings.

To provide additional context, non-traditional sources were also reviewed including astronaut memoirs, interviews, mission de-briefings and descriptive reports related to commercial spaceflight activities.

3.3. Data Analysis and Integration

From the selected sources, data were gathered on major psychological stressors, emotional and behavioral reactions, available counter-measures and areas where evidence was sparse or inconsistent. The analysis focused on recurring themes observed across different types of mission and operational settings.

Comparisons were made between governmental and commercial missions, spaceflight and terrestrial analogs and crews with varying levels of training and institutional support. Special attention was given to factors affecting crew morale, interpersonal relationships and individual coping strategies in isolated, confined and extreme (ICE) environments.

4. RESULTS

4.1. Crew Morale Dynamics and the Third Quarter Phenomenon

Studies of both spaceflight and terrestrial analogs reveal a recurring pattern in crew morale, though its timing and intensity vary across missions. Morale typically starts high, fueled by novelty and initial excitement, with strong team cohesion and effective coping strategies. As missions enter the mid-phase, morale often declines reaching a low point commonly referred to as the "third-quarter phenomenon". This stage is marked by fatigue, irritability, interpersonal tension and heightened psychological strain occurring after the initial excitement has diminished but before the mission is nearing its end. In the final months, morale generally improves driven by anticipation of returning home and achieving mission goals. While the exact timing and degree of these changes differ among crews and missions, this overall pattern offers a valuable framework for understanding psychological adaptation during extended periods of isolation and confinement.

4.2. Prevalence of Psychological Issues across Populations

Figs. 3 and 4 compare the incidence of common psychological issues (anxiety, depression, sleep disturbances and cognitive fatigue) among three groups: astronauts, participants in analog environments and the general population using data from NASA and ESA. The findings highlight the effectiveness of stringent astronaut selection and in-mission psychological support programs. Due to screening for psychological resilience and availability of structured support, astronauts generally show lower rates of anxiety and depression compared to the analog participants and the general public [Albornoz-Miranda et al., 2023; Pagnini & Grosso, 2025]. This suggests that the risk of serious mental health disorders among space travelers is substantially reduced by the preventive and ongoing support measures in place. Fig. 3, however, indicates that some issues such as cognitive fatigue and sleep disturbances remain relatively common among astronauts. These challenges are linked to the unique physiological and environmental stressors of spaceflight including the altered circadian rhythms, microgravity related sleep disruptions and the demanding cognitive workload of mission tasks [Le Roy et al., 2023; De la Torre et al., 2024]. In contrast, participants in terrestrial analog environments often show higher prevalence rates across most psychological conditions despite experiencing similar isolation and confinement. This difference probably reflects the less rigorous selection processes and potentially lower levels of psychological support in many analog studies. The general population serves as a baseline for comparison as they do not face the extreme stressors of the ICE environments nor receive specialized selection or support. While they typically show higher rates of anxiety and depression than astronauts, rates of sleep disruption and cognitive fatigue can be similar or lower depending on lifestyle factors. Overall, even in a carefully selected and well-supported astronaut population, these findings underscore the ongoing need for targeted interventions to address specific psychological vulnerabilities in spaceflight.

Considering the qualitative data from NASA and ESA mission reports, these plots illustrate the frequency of psychological issues occur in astronauts and the similar groups (such as Antarctic expeditions, submarine crews and simulated mission participants) as well as the general population. Seven complementary plots are presented. In particular, the scatter plot in Fig. 5 compares the prevalence of psychological challenges (including anxiety, depression, sleep disturbances and cognitive fatigue) across astronauts and the similar groups. Trends mentioned in NASA and ESA sources are the source of the data. Because of their rigorous selection and in-mission assistance, astronauts typically report lower rates of anxiety and depression, but analog populations, which do not have the same selection rigor, frequently show higher prevalence, as the image shows. Both groups, however, exhibit ongoing susceptibility to cognitive exhaustion and sleep disorders. Fig. 6 shows a scatter plot comparing the prevalence of psychological issues (anxiety, depression, sleep disorders, and cognitive tiredness) among astronauts and the general population. Astronauts generally had lower rates of anxiety and depression than the general population, according to estimates based on NASA and ESA data, which reflects successful selection and support strategies. However, the astronauts still experience relatively higher rates of sleep disturbances and cognitive fatigue because of the physiological and environmental stressors such as microgravity and disrupted circadian rhythms. Fig. 7 presents impact-weighted variations in the prevalence of psychological issues across the astronauts, the similar group and the public. When combining the relative occurrence and severity weightings, this figure highlights how different psychological stressors affect each group differently. For example, the astronauts are less prone to anxiety and depression, but the demands of space missions make sleep and cognitive difficulties more impactful suggesting that their risk profile differs from both the similar participants and the general population.

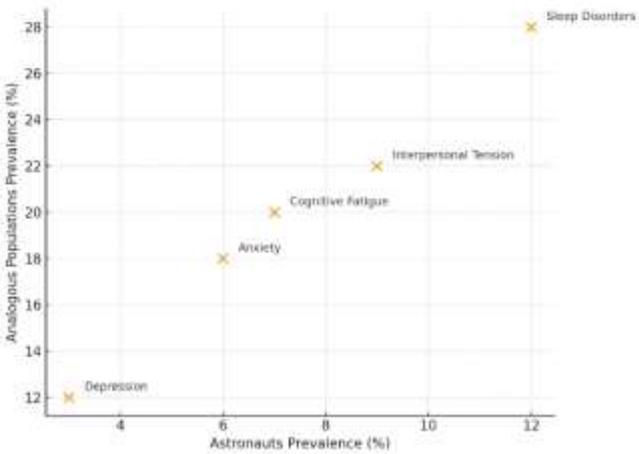

Fig. 5: A scatter plot comparing astronauts as a function of analogous.

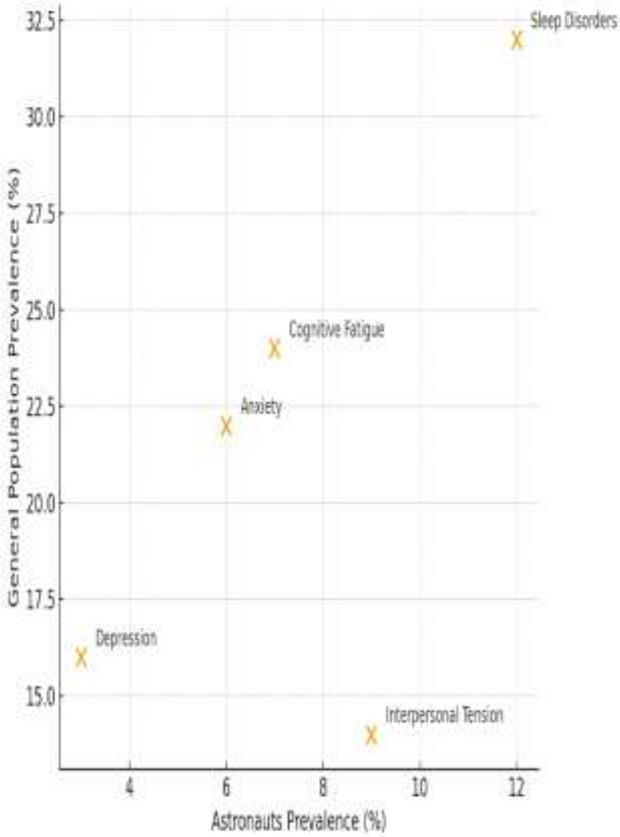

Fig. 6: A scatter plot comparing astronauts as a function of the general population

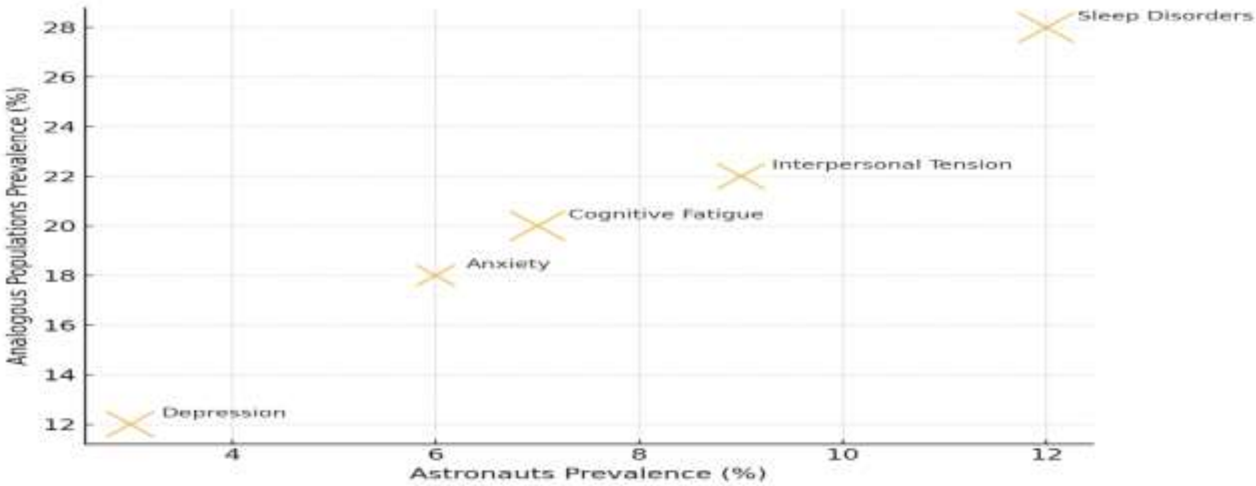

Fig. 7: Impact-weighted difference.

Table 1: Comparative Overview of Psychological Assessment and Support in Spaceflight

Feature / Entity	NASA [1] (Professional Astronauts)	ESA[2] (Professional Astronauts)	SpaceX[3] (Inspiration4 - Civilian)	Blue Origin[4] (Suborbital - Civilian)	Virgin Galactic[5] (Suborbital - Civilian)
Selection & Screening	Rigorous psychological resilience, stress	Similar to NASA, focus on psychological and	Medical and psychological screening,	Medical screening, likely basic	Medical screening, likely basic

	resistance, social competency. Extensive medical & psychological evaluations.	social competency, cultural background.	but less extensive than professional astronauts.	psychological readiness.	psychological readiness.
Pre-flight Training	Extensive psychological preparation, team-building, stress management, analog missions.	Comprehensive training, including analog missions (e.g., Mars500, Concordia).	Mission-specific training, including emergency procedures and some psychological prep.	Brief training focused on safety and flight experience.	Brief training focused on safety and flight experience.
In-mission Monitoring	Remote monitoring, private psychological conferences, computer-based cognitive assessments.	Monitoring in analog missions, research on cognitive performance and team dynamics.	Neurocognitive tests (e.g., Cognition app), physiological markers (HRV, blood oxygen).	Limited public data, likely basic health monitoring.	Limited public data, likely basic health monitoring.
Psychological Support	Individually-determined support, family assistance, C-O-N-N-E-C-T framework.	Focus on team dynamics, cultural integration, countermeasures for isolation.	Support for crew and families, debriefings.	Limited public data, likely reactive support if needed.	Limited public data, likely reactive support if needed.
Key Stressors Addressed	Isolation, confinement, altered circadian rhythms, workload, interpersonal dynamics.	Isolation, confinement, cultural differences, performance under stress.	Novelty of spaceflight, physical demands, public visibility.	Novelty, physical sensations of launch/re-entry, brief microgravity.	Novelty, physical sensations of launch/re-entry, brief microgravity.
Data Availability	Extensive public reports, research papers, long-term studies.	Public reports from analog missions, research papers.	Penn Medicine study on Inspiration4, some public data.	Limited public data on psychological aspects.	Limited public data on psychological aspects.

Sources:

1. https://www.nasa.gov/reference/jsc-behavioral-health/
2. 2.https://www.esa.int/Enabling_Support/Preparing_for_the_Future/Space_for_Earth/Space_for_health/Psycho-sociological_issues_Cognition_and_performance
3. https://penntoday.upenn.edu/news/penn-medicine-first-study-civilian-space-crew-charts-course-research-commercial-flight-heats
4. https://www.sciencedirect.com/science/article/abs/pii/S2352309321000067
5. https://www.sciencedirect.com/science/article/abs/pii/S2352309321000067

4.3. Discussion

Although rigorous selection and support programs reduce the risk of severe psychological issues, some residual strain persists. Astronauts often experience temporary declines in sleep quality and working memory that are not completely addressed by existing counter-measures (Barger et al., 2014). These effects likely stem from stressors that cannot be fully modified, such as artificial light-dark cycles, exposure to vibration and noise and the cognitive demands of constant vigilance. At the same time, the growth of commercial human spaceflight calls for updates to existing models. Civilian participants, for example those on Inspiration 4, typically do not undergo standardized psychological screening but often show strong intrinsic motivation and psychosocial flexibility. Early evidence suggests that resilience in these crews may rely less on pre-selected traits and more on coping strategies and team cohesion (Jones et al., 2023). Consequently, future support frameworks will need to account for heterogeneous crew compositions, varying mission lengths and diverse operational goals shifting from one-size-fits-all protocols to dynamically tailored behavioral health strategies.

4.4. Psychological Screening, Training, and In-Mission Support in Human Spaceflight

4.4.1. Selection and Psychological Screening

The selection protocols of astronaut emphasize the psychological suitability an essential requirement and equally important as the medical and technical qualifications. Due to the increasing demands of spaceflight such as extended isolation, confinement, high autonomy and interdependent teamwork, candidates must show strong emotional regulation, interpersonal adaptability and the ability to tolerate prolonged uncertainty without declines in performance (Palinkas & Suedfeld, 2008). Empirical data from spaceflight and analog environments (e.g., Antarctic winterovers, HERA, NEK) indicate that traits such as emotional stability, cooperative problem-solving and cognitive flexibility are significant predictors of successful long-duration adaptation (Sandal et al., 2018). Epidemiological comparisons further reveal that flown astronauts exhibit substantially lower incidence rates of clinically significant anxiety and depression relative to both analog participants and age-matched population controls (Kanas & Manzey 2008; Stuster

2016). This would suggest that current multistage screening typically involving structured interviews behavioral observation in team tasks, and psychometric assessment is effective in identifying candidates with high baseline resilience and low vulnerability to stress-induced dysfunction.

4.5. Pre-Flight Psychological Preparation

Psychological readiness before launch is developed through coordinated set of preparatory measures aimed at strengthening adaptive capacity and ensuring that crews enter mission with practical tools for managing prolonged operational demands. Instead of treating resilience as a fixed trait, training programs actively develop it through multiple complementary approaches. These programs integrate cognitive and behavioral techniques to enhance emotional regulation, maintain attention and build tolerance for fatigue along with training targeting the interpersonal skills. In addition, special emphasis is placed on cross-cultural communication and managing interpersonal tensions reflecting the challenges faced by multinational crews living and working in confined environments (De La Torre et al., 2024).

Experiential training is a core element of this preparation. Crews engage in extended stays in similar environments designed to simulate the psychological stressors of spaceflight including limited sensory variation, disrupted light-dark cycles, social confinement and delayed communication with mission control. The ESA's CAVES program, NASA's HERA habitat and CNSA's Lunar Palace-1 offer controlled settings where astronauts can face these challenges and practice adaptive behavioral strategies before the actual mission is deployed.

The preparation is further tailored through personalized psychological readiness profiles. These profiles combine self-reported stress sensitivities, coping strategies and the challenges anticipated during each phase of the mission. Behavioral health specialists continuously monitor the psychological readiness throughout training using observational data and structured self-report measures. This approach enables support strategies to be refined over time to ensure that the psychological preparation adapts to the evolving demands of the mission rather than remaining fixed at the point of selection.

4.6. In-Mission Psychological Support

Psychological care during space missions is delivered through an integrated operational model designed to preserve functional capacity and identify emerging stress responses before they become operationally relevant. Rather than relying on a single intervention pathway this model combines anticipatory measures responsive support and continuous observational inputs. A central element is the routine provision of confidential psychological consultations with ground-based clinicians generally conducted at regular intervals complemented by formalized communication channels that sustain interpersonal connection with family and social networks on Earth.

The spacecraft environment itself is actively used as a regulatory tool. Adjustable lighting systems are implemented to stabilize circadian timing while planned physical activity schedules and controlled access to recreational media contribute to emotional regulation and cognitive continuity. These measures are not treated as optional comforts but as functional components of behavioral health maintenance.

In recent missions these approaches have been augmented by unobtrusive monitoring of physiological and behavioral indicators. Sleep wake patterns derived from autography autonomic markers such as heart rate variability speech-based stress indicators and repeated computerized cognitive assessments are used to track deviations from each astronaut's established baseline. Importantly these data streams do not operate as automated decision systems. They serve instead as contextual inputs interpreted by clinical professionals ensuring that behavioral health oversight remains grounded in expert judgment rather than algorithmic thresholds.

Across the full history of human spaceflight, no mission has required termination due to an acute psychiatric crisis. Although transient effects including sleep fragmentation irritability and short-lived reductions in attentional stability have been observed these disturbances have remained operationally contained. Their limited impact reflects the cumulative effectiveness of rigorous selection procedures combined with sustained in-flight psychological support.

5. CONCLUSIONS

We investigate the development of psychological strain during space missions and find that it emerges gradually, and can persist over time. We conclude that this pattern differs from everyday stress on Earth. We identify prolonged isolation, restricted movement, limited sensory input and continuous operational demands as key factors affecting sleep, emotional stability, and cognitive performance and crew interactions.

We examine evidences from spaceflight and simulations and find that even highly trained individuals are not immune of these effects. We observe that psychological responses vary across individuals and missions. We identify a commonly reported decline in morale during the later stages of a mission, referred to the third-quarter phenomenon. We note that its timing and intensity inconsistent. We therefore conclude that psychological adaptation is highly individual rather than tied to a fixed timeline.

We argue that variability necessitates flexible behavioral health support. We find that that rigid systems are less effective in such environments, while adaptive approaches respond more effectively to change stress levels, coping strategies and group dynamics. Although astronauts are generally resilient, temporary issues such as sleep disruption, reduced focus and emotional fluctuations still occur indicating that current measures mitigate risk but do not eliminate it.

We further investigate recent strategies and find a shift toward continuous monitoring rather than the fixed intervention points. We highlight that advances in adaptive support systems and wearable technologies allow earlier detection of subtle physiological and psychological changes. We also find that spaceflight can produce positive psychological outcomes including increased reflection, a stronger sense of connection and renewed purpose.

As missions extend to the Moon and Mars, both the benefits and challenges such as communication delays and extreme isolation are likely to intensify. A balanced understanding is essential: while risks are real, the environment can also support personal growth. Future success will depend on flexible and individualized support systems.

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