CLOSING REGULATORY GAPS IN SPACE LAW: A FRAMEWORK FOR ASTRONAUT HEALTH PROTECTION

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Abstract

Deep-space exploration is the branch of astronomy, astronautics and space technology for exploration of distant regions of outer space. It consists of missions beyond Earth's atmosphere to deepen our understanding of the universe. These missions are beneficial in a wide range of areas monitoring security, health and many more involving both human spaceflight missions and robotic missions. The long-duration journeys away from earth orbit subject astronauts to considerable long-term health threats such as increased cancer risk from galactic cosmic radiation and solar particle interactions, cardiovascular deterioration, muscle and bone loss, neuro-ocular syndrome, and various physiological and psychological impacts resulting from extended periods of microgravity and isolation.

Existing regulatory frameworks do not sufficiently provide physiological and psychological health related protection to astronauts, they primarily focus on immediate damages, state accountability and liability for direct, acute harm resulting from space activities. They give limited or no specific guidelines for chronic, latent or delayed health issues that could emerge years or even decades after the mission. This results in substantial gaps in astronaut protection and legal accountability.

This paper is divided into three parts. The first part deals with analysis of existing legal frameworks and their limitations regarding long-term health protection. The second part discusses identification and examination of legal gaps including telemedicine licensing, cross-jurisdictional medical practice regulations for multinational crews, unclear

mechanisms for attributing medical responsibility and liability in collaborative missions involving state and private actors, lack of standardised insurance models or compensation frameworks capable of addressing post-mission health claims, including long-latency diseases. The third part of this paper analyses emerging challenges in multinational and commercial deep space missions and areas that need to reform for enhancing accountability, ensure equitable risk distribution, and facilitate sustainable human space exploration. As per the analysis, there is a need for rules to ensure health protection of spacecraft personnel along with existing rules.

Keywords: Astronaut Health; Space Law; Telemedicine; Legal Liability; Space Governance; Health Insurance; Human Spaceflight

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I. INTRODUCTION

Space Medicine is a branch of medical science that deals with medical problems encountered beyond the earth's atmosphere. Space medicine evolved from aerospace medicine.[1] Hubertus Strughold introduced the term “space medicine” in 1948, nine years before Sputnik I’s launch, during a panel organised by Col. Harry G. Armstrong on the aeromedical challenges of space travel.[2] This emerging field has focused on the physiological and psychological challenges of spaceflight.

Gradually, space medicine has evolved from monitoring astronaut health to conducting research to researching counter-measures and systems that enable humans to survive and function safely in space’s extreme environments, such as microgravity and high radiation. It addresses vital issues such as microgravity induced bone and muscle loss, cardiovascular damage, cancer risk (radiation carcinogenesis), central nervous system (CNS) degeneration which causes cognitive impairment or accelerated neurodegenerative diseases. It also includes isolation related psychological effects, and behavioural health issues due to long duration missions.[3]

[1] Britannica, *Aerospace Medicine*, (Apr 8, 2019), https://www.britannica.com/science/aerospace-medicine.

[2] Lily Srivastava, *Space Medicine and the Law*, in *Current Developments in Air and Space Law* 284, 284 (Ranbir Singh, Sanat Kaul & Srikrishna Deva Rao eds., 2012).

[3] Britannica, *supra* note 1.

The World Health Organisation defines health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." This definition also applies to astronauts, whose well-being is necessary for mission success and safe return[4]. Even if the manned space exploration is limited and only achieved independently by only a few nations, these missions have provided important data on space travel's impacts on the human body, informing possible countermeasures, biomedical support systems, telemedicine and crew health protocols.

II. Existing International and Indian Frameworks for Astronaut Health Protection

Over time, India's space activities have progressed through various phases from conceptual, experimental, operation commercial and further expansion phases. With each stage, the demand for space systems, applications, and services to meet national priorities and global opportunities has grown rapidly[5] resulting in increased involvement of Indian industry and service providers, who play a more important role in diverse space initiatives under the technical guidance and authorisation of the Department of Space[6]. In India, the growing space program, like the Gaganyaan human spaceflight mission, international collaborations such as Indian astronaut Shubhanshu Shukla's participation in Axiom Mission 4 and ambitions for sustained exploration has increased the relevance of space medicine.

India has advanced space medicine through institutions like the Institute of Aerospace Medicine (IAM) under the Indian Air Force in coordination with ISRO, which conducts astronaut selection, training, physiological studies and research. Recent collaborations, such as ISRO's framework agreement with the Sree Chitra Tirunal Institute for Medical Science and Technology (under the department of Science and Technology), focus on human physiological and behavioural health studies, radiation biology, countermeasures, telemedicine and crew medical kits increasing academia-industry partnerships in medical device development and space health research[7]. It will form the opportunity in enhancing the

[4] Reddy Sai Spandana, *Space Medicine and Law: Emerging Trends and Challenges*, 3 Int'l J. Legal Sci. & Innovation 223, 224.
[5] Draft Space Activities Bill, 2017, Bill No. 2 of 2017 (India).
[6] Draft Space Activities Bill, 2017, Bill No. 2 of 2017, cl. 3 (India).
[7] Indian Space Research Organisation (ISRO), Department of Space (DoS) & Sree Chitra Tirunal Institute for Medical Sciences & Technology., Department of Science and Technology., *Framework Memorandum of Understanding on Cooperation in Space Medicine* (Apr. 25, 2025).

study of space medicine and at the same time it points towards the need for a strong framework for long term health protection of astronauts.

India is a part of major international space treaties, including the Outer Space Treaty (1967)[8], the Agreement on the Rescue of Astronauts (1968)[9], Liability Convention[10] and Registration Convention[11]. Article V of the Outer Space Treaty obligates assistance and safe return of astronauts in distress regardless of nationality.[12] Under the Outer space Treaty, states are required to authorise and exercise continuing supervision over activities of non-governmental entities in outer space, including the Moon and other celestial bodies, adhering to treaty's provisions. The responsibility of all national space activities, whether conducted by government agencies or private actors, is carried by states according to it.[13]

In India, however, there is still no comprehensive national legislation specifically regulating space activities. The current framework relies on constitutional provisions that allow for the implementation of international treaties along with policies such as the Satellite Communications Policy, 2000[14] and the Revised Remote Sensing Data Policy, 2011. While other space faring nations have built legal frameworks to look after and regulate their national programs[15], Indian Space Policy 2023 and IN-SPACe guidelines guide space activities as only a framework[16], and not as a legislation or a statute.

The Indian government has recognised this gap previously and considered the need for a law to regulate and support the country's expanding space activities. In November 2017, it released a draft Space Activities Bill[17] for public consultation to invite feedback from stakeholders, but lapsed without introduction in Parliament. Section 5(j) of the bill mandates "safety requirements and safety measures in relation to any space activity," and Section

[8] Treaty on Principles Governing the Activities on States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205.
[9] Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, Apr. 22, 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119.
[10] Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187.
[11] Convention on Registration of Objects Launched into Outer Space, Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15.
[12] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies Art. V, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205.
[13] Outer Space Treaty, *supra* note 13, art. VI.
[14] Department of Space, *Norms, Guidelines and Procedures for Implementation of the Policy Framework for Satellite Communications in India.*
[15] Rima Hore, *A Critique of the Draft Space Activities Bill, 2017*, at 87.
[16] Department of Space, Government of India, *Indian Space Policy 2023*, at 11 (2023)
[17] Department of Space, Government of India, *Draft Space Activities Bill,* (2017).

7(2)(a) makes sure activities "do not jeopardise public health or the safety of individuals or property[18]," but these are general and do not talk about radiation exposure, microgravity effects, psychological well-being, or occupational health for space personnel.

Reform efforts have been initiated through the creation of IN-SPACe's[19] and the Indian Space Policy 2023[20]. These policies promised to make new laws but prioritised guidelines such as NGP 2024 for private sector[21]. As the government develops sector specific standards for e.g. safety catalogues first such policies remain pending. These bills aimed at increasing innovation and entrepreneurship within the space industry and focused on licensing commercial space activities, safety requirements for operations like preventing public health risks or environmental damage from launches and conformity with international treaties. The specific provisions for astronaut health standards, psychological well-being, ethical protocols for long duration flights or dedicated occupational health frameworks do not exist.

Space missions such as Gaganyaan, are being carried out under the authority of executive decisions and policies made by the government. With the rapid development of space programs, and milestones like the Gaganyaan, human spaceflight mission, ambitions for long-term exploration highlights the importance of space medicine along with space health. While India has made progress in space medicine research and training through institutions like the Institute of Aerospace Medicine (IAM) under the Indian Air Force, and collaborations with ISRO, there is currently no space health law or specific statutory framework in India that fully regulates astronaut health standards, medical protocols, radiation limits, ethical concerns for long-duration flights or liability in health-related incidents during space activities. The absence of a dedicated legal framework for astronaut health in India must also be understood in relation to the broader global landscape of human spaceflight, where participation itself remains highly restricted. Manned-space exploration is also limited, only three countries so far have succeeded in man space missions. These missions have helped space scientists, doctors and surgeons observe, analyse and establish certain psychological and physiological impacts space travel has had on human body[22].

[18] *Indian Space Policy 2023*, *supra* note 17, §§ 5(j), 7(2)(a).
[19] Indian National Space Promotion & Authorization Centre (IN-SPACe), Department of Space, Government of India, IN-SPACe.
[20] *Indian Space Policy 2023*, *supra* note 17.
[21] Indian National Space Promotion & Authorization Centre (IN-SPACe), Department of Space, Government of India, *Norms, Guidelines and Procedures for Implementation of Indian Space Policy 2023 in Respect of Authorization of Space Activities (NGP)* (May 2024).
[22] Spandana, *supra* note 4, at 228.

III. Core Legal Gaps in Astronaut Health Regulation

Institute of Aerospace Medicine IAF Bangalore has defined areas of work including Isolation and Psychological Management, Microgravity research, Clinical Space Medical and Surgical Management, Radiation Protection, and Operational Space Medicine to support the Human Space Programme (HSP) of ISRO[23]. As pointed out by Prof. K. Kasturirangan, "In a space environment, human beings face micro-gravity conditions, which alter the flow, quantity, and distribution of body fluids, being free of the gravitational effect." It underlines the emerging field of space medicine, which tries to solve physiological challenges which are very different from extraterrestrial environments. The legal frameworks governing space activities remain underdeveloped while medical science begins to adapt these conditions, leaving gaps in regulation, liability and ethical concerns[24].

The evolution in human spaceflight has been seen from the short-duration missions on the International Space Station (ISS) which spanned to months with a stable multinational crew under unified command to the long-duration, deep-space multinational operations. Programs such as NASA's Artemis program, Mars analog simulations, and emerging private orbital stations such as Axiom Space or Starlab introduce extended exposure to microgravity, radiation, psychological stressors, and isolation, compounded by diverse crews from state agencies and private entities operating across jurisdictions. These changes increase the complexities of medical care delivery, demanding a review of existing legal frameworks[25]. These limitations reveal four core gaps, examined next.

A. Telemedicine and Licensing Deficiencies

Telemedicine is a field in which telecommunication technologies and medicine interact to allow for the provisions of health care remotely. It can be used for remote consultation between physicians or between physicians and patients regardless of geographic distance[26].

NASA has prioritised telemedicine, first using it to monitor astronauts' health through data transmission and remote communication and has now grown into something much more advanced.[27] Today's smart medical systems are being developed that not only track and

[23] Srivastava, *supra* note 2, at 286.
[24] Srivastava, *supra* note 2, at 286.
[25] Justin Zadorsky, *Western Researchers Call for Better Physician Licensing System to Address Medical Care in Space* (Feb. 28, 2023.)
[26] Britannica, *Telemedicine,* https://www.britannica.com/science/telemedicine (last visited Mar.1, 2026).
[27] Andrew T. Simpson, Charles R. Doarn & Stephen J. Garber, A Brief History of NASA's Contributions to Telemedicine (Mar. 26, 2020).

diagnose health conditions in space but also allow doctors on Earth to provide limited treatments from afar. It also enables physicians on Earth to remotely deliver limited treatments. This blending of communication functions and therapy marks a step forward for the future of human spaceflight, and it also has huge potential for emergency care in remote regions on Earth.

India's telemedicine journey started in the late 1970s with the Satellite Instructional Television Experiment, using NASA's Application Technology Satellite (ATS-F) the program connected over 2,000 villages across the country. It wasn't only limited to medicine, it brought education to rural communities, covering a wide range of topics like health, hygiene, adult learning and rural development. This helped to create the base for India's future in telemedicine and digital healthcare[28].

Astronauts on the International Space Station (ISS) stay connected with doctors on Earth by the communication systems that allow telemedicine. Living in space for long periods has a major impact on the body. It affects cardiovascular, vestibular, and musculoskeletal systems. Bones get weaker, losing about 1 to 3% of their strength each month, and muscles shrink by around 5% each month. After just a few weeks, the body also uses about 25% less oxygen than it normally would on Earth[29].

The partner space agencies on the International Space Station (ISS) such as National Aeronautics and Space Administration (NASA), European Space Agency (ESA), Canadian Space Agency (CSA), Russian Federal Space Agency (Roscosmos), and Japan Aerospace Exploration Agency (JAXA) have agreed on basic health rules such as ISS legal framework, International Space Station Intergovernmental Agreement, Memorandums of understandings and bilateral arrangements between partner agencies. These rules are based on international agreements and a shared Code of Conduct, setting minimum standards for crew health and safety. Countries also have their own programs, like the U.S. TREAT Astronauts Act or Canada's Health Beyond Initiative, and efforts to modernise astronaut medical records. These national initiatives help to tackle health challenges astronauts face in deep space, but they only apply within each country's system and don't extend internationally[30].

[28] Bhaskarnarayana, L.S. Satyamurthy & Murthy L.N. Remilla, Indian Space Research Organization and Telemedicine in India, Vol. 15, No.6, https://doi.org/10.1089/tmj.2009.0060 (Aug. 1, 2009).
[29] K. Ganapahty, Space Medicine: The Ultimate in Remote Healthcare, Telehealth & Med. Today, at 3, Space Medicine: The Ultimate in Remote Healthcare | Telehealth and Medicine Today (2020).
[30] Abeer Malik, *Housten, Do We Have a Lawyer? The Legal Black Hole of Astronaut Health Care,* Houston, Do We Have a Lawyer? The Legal Black Hole of Astronaut Health Care - Petrie-Flom Center (Apr. 3, 2025).

The International Space Station shows that countries can work together on space medicine, but the system is still not fully developed. Each space agency still follows its own rules, which means protections for astronauts and responsibility if something goes wrong are scattered across different national policies. Researchers point out that while countries like the U.S. and Russia have strong laws to safeguard astronaut's health and mental wellbeing, these protections don't line up internationally[31]. These measures lack international cohesion, therefore problematic for multinational crew missions or missions beyond ISS. There is a regulatory void leaving both astronauts and doctors at risk as no Earth- based medical licence explicitly covers deep space. Terrestrial telemedicine laws are limited to national borders and there is no clarity of legal jurisdiction.[32]

Telemedicine rules for space missions are built on Earth's patchwork of national systems, and that leaves a huge gap. In the U.S., doctors are licensed state by state. The Interstate Medical Licensure Compact[33] makes it easier to work across states, but physicians still need separate fees, background checks, and approvals especially for telehealth. In Europe, doctors are licensed nationally too, with some coordination through EU directives[34]. But differences between countries remain, and strict privacy laws like General Data Protection Regulation (GDPR) create extra hurdles, much like Health Insurance Portability and Accountability Act (HIPAA) does in the U.S. None of these systems even consider medical care beyond earth[35]. Right now, no medical licence on Earth officially covers deep space, unlike aviation medicine where countries recognise each other's standards through International Civil Aviation Organisation (ICAO).[36] There is no global agreement for "space medicine." This becomes an issue for deep-space telemedicine. Realtime consultations become impossible because communication delays to Mars range from 4 to 24 minutes one way [37]. Astronauts will have to rely on delayed instructions, onboard medical autonomy, and flight surgeons whose licences don't legally extend into space. That leaves unanswered questions about which laws apply,

[31] Holm, *Legal Protections for the Health of Astronauts: An Analysis* 98 (Inst. of Air & Space Law, McGill Univ. Faculty of Law, 2020).
[32] Zadorsky, *supra* note 25.
[33] Interstate Med. Licensure Compact, *States Information* States Information | Interstate Medical Licensure Compact, (2021).
[34] Vera Lúcia Raposo, *Telemedicine: The Legal Framework (or the Lack of It) in Europe*, GMS Health Tech. Assessment, https://pmc.ncbi.nlm.nih.gov/articles/PMC4987488/ (Aug. 16, 2016).
[35] Robb Taylor-Hiscock, *HIPAA vs. GDPR Compliance: What's the Difference?* (Sept. 21, 2022).
[36] International Civil Aviation Organisation, (ICAO), International Civil Aviation Organization (last visited Apr. 4,2026).
[37] Madison Diamond; Gloria R. Leon; Pablo de León, *Mars Mission Communication Delays and Impact on Mission Controller Performance, Workload, and Stress*, 96 Aerospace Medicine & Human Performance (2025).

who is responsible, and how accountability works when multinational crews face medical emergencies far from Earth.

India is uniquely positioned and needs to close this gap with a national telemedicine licensing framework for deep-space missions. India has already built a foundation to take telemedicine in space The Indian Space Research Organisation has been working on telemedicine using satellites since 2001, and in 2020 the National Medical Commission has given clear Telemedicine Practice Guidelines. The country has already developed the technical infrastructure via INSAT and GSAT satellite networks and a mature regulatory framework[38]India is well prepared to increase these capabilities beyond low-Earth orbit. A dedicated licensing system for space medicine would do several things including giving Indian doctors and flight surgeons clear legal authority to treat astronauts in space without worrying about jurisdiction issues. Build in training and protections for unique risks like communication delays, radiation and microgravity. It will help India in future bilateral and multilateral deep- space ventures accelerating innovation in space-health technologies, and will ensure that Indian astronauts and collaborating international crew members receive legally strong support.

B. Cross-Jurisdictional Practice Barriers

Today's space missions majorly bring together astronauts from many countries, all living and working inside the same spacecraft. Crew members from the NASA, Roscosmos, ESA, JAXA, and CSA share one home in orbit on ISS, even if each still follows their own nation's medical rules[39]. Things get more complicated with the joining of new private players like SpaceX, Axiom, and private astronauts. Physicians, flight surgeons, and medical officers trained under different national protocols are carried by a single spacecraft, yet all are required to respond instantly to the same microgravity emergency, radiation event, or psychological crisis[40].

The absence of a unified extraterritorial medical regulatory regime is a major regulatory gap behind this operational unity. The 1998 ISS Intergovernmental Agreement (IGA) and its supporting Memoranda of Understanding and multilateral Code of Conduct includes

[38] Utkarsha Mahajan, *India in Space for Health: A Case of Tele-Medicine and Tele-Health* India in Space for Health: A Case of Tele-Medicine and Tele-Health (Aug. 2, 2021).
[39] Malik, *supra* note 30.
[40] Adam Mann, *Human Spaceflight's New Era Is Fraught with Medical and Ethical Questions* Human spaceflight's new era is fraught with medical and ethical questions (June 11, 2024).

operational coordination, safety baselines, and jurisdiction rules. The right of Jurisdiction and control of each partner state over the elements it registers and over its own nationals aboard the station is granted by Article 5 of the IGA[41]. But the agreement defers medical standards of care, licensing, data privacy, informed consent and record-keeping to each national space agency. There is absence of code or treaty implying a common standard of care once the isolation begins[42].

Handling of astronaut health and research varies by space agencies. In the U.S. laws like the Privacy Act of 1974 make medical records very private. NASA has treated astronaut health information as highly sensitive, and historically produced under-reporting of clinical signs and symptoms. A 2001 National Academics report even noted that astronauts felt pressure not to disclose health issues worrying it will lead to disqualification from future flights[43]. In contrast, Russian protocols adopt broader psychophysical ideas such as "asthenia"[44] (a kind of fatigue or weakness) and sets different standards for when mental health care or research involvement is needed. For Europe's astronauts, ESA crew medical officers operate under the EU's Personal Data Protection framework[45]. These differences also show up in research ethics. American astronauts may refuse to take part in studies during missions, while in other agencies, being part of such studies is often seen as their duty.

During missions, these differences in medical privacy and research ethics may present serious difficulties. The U.S. medical programs and Russian protocols might be different towards approaches to prevention, treatment, and participation in research[46]. Consent in medical conditions also becomes tricky when experimental treatments are suggested, astronauts from different countries may disagree because their cultures and laws define personal choice and autonomy differently. In psychological cases, depression caused due to isolation or

[41] Agreement Among the Government of Canada, Governments of Member States of the European Space Agency, The Government of Japan, The Government of the Russian Federation, and the Government of the United States of America Concerning Cooperation on the Civil International Space Station, Jan. 29, 1998, T.I.A.S. No. 12927, at 5.
[42] Charles R. Doarn et al., A Framework for Multinational Medical Support for the International Space Station: A Model for Exploration, 92 Aerospace Medicine & Human Performance, (2021).
[43] National Academies of Sciences, Engineering, and Medicine, *Safe Passage: Astronaut Care for Exploration Missions* 174 (2001).
[44] NASA, *Human Health and Performance Risks of Space Exploration Missions: Evidence Reviewed by the NASA Human Research Program* 8, NASA SP-2009-3405.
[45] European Space Agency (ESA), *Highlights of ESA Rules and Regulations*, ESA - Highlights of ESA rules and regulations.
[46] Institute of Medicine, *Astronaut Care for Exploration Missions* (John R. Ball & Charles H. Evans, Jr. eds., 2001).

interpersonal conflict can trigger grounding recommendations under one nation's mental-health standards while another might not see it as serious enough. Problems continue after missions too, sharing medical data for research like studying bone loss, vision changes or psychological health is often blocked by national privacy rules.

The main space treaties like the 1967 Outer Space Treaty, The Rescue Agreement and the Liability Convention address the state responsibility for "activities" in outer space only in the broadest terms. They have no particular regulations pertaining to extraterritorial licence of medical practice[47]. The Artemis Accords, joined by India in 2023, support the emergency assistance requirements and promote safety zones but say nothing about medical jurisdiction, standards of care, or cross-national physician licensing. Things get even more complicated with private companies joining space missions. Their astronauts may fall under even less harmonised corporate medical oversight.

The consequences are serious and immediate. If crew members lose trust or unity in a stressful, isolated environment of space their performance and safety can suffer. Real time decision making in medical emergencies becomes slower and more controversial when flight surgeons have to deal with conflicting national guidelines. This cross-jurisdictional ambiguity also raises the question about who ultimately bears the medical responsibility and liability when multiple state and private actors collaborate.

India is still new to human spaceflight, with its Gaganyaan program aiming to send three astronauts on its first independent mission[48], with no multinational crew, medical oversight falling under Indian authority. The Institute of Aerospace Medicine (IAM) under the Indian Air Force in close collaboration with ISRO's Human Space Flight Centre looks after astronaut selection, physiological training, real-time health monitoring through telemedicine and bio-vests, radiation protection, emergency protocols, and crew healthcare systems[49]. India is also building its own expertise in space medicine, Recent collaboration of ISRO with Sree Chitra Tirunal Institute for Medical Sciences & Technology (SCTIMST) focuses on research into human physiology, behavioural health, radiation biology, microgravity effects and biomedical support according to India's needs and priorities. India depends a lot on partnerships with other countries to cover medical rules rather than setting rules by itself. By signing the

[47] Malik, *supra* note 30.
[48] ISRO, *Gaganyaan* (Nov. 23, 2022).
[49] Institute of Aerospace Medicine, *supra* note 7.

Artemis Accords in 2023[50], India agreed to principles of safe and transparent exploration, but the Accords don't cover medical rules or liability issues in multinational missions[51].

India adopts a pragmatic approach abroad by collaborating with different partners based on particular needs through targeted cooperation, examples of this include NASA's assistance with astronaut training[52], space medicine cooperation with France's CNES[53], previous training ties with Russia's Roscosmos and even Australian Space Agency in recovery planning[54]. This represents India's broader strategic stance, keeping its strategic autonomy[55], bilateral arrangements over multilateral regimes, and inclusive policies. But India hasn't yet adopted foreign medical standards into its own system. India hasn't taken any stance on whether there should be a single global medical system for space missions, but its emerging role positions it uniquely. With plans for the Bhartiya Antariksh Station (BAS) starting module launches around 2028 and full operations by the mid 2030's, India sees BAS as a national but also an open platform for microgravity research in life sciences and medicine[56]. This could give India the chance to set common medical protocols if it invites global partners, helping bridge the gaps between Western, Russian and emerging standards. India is handling the cross-jurisdictional challenges carefully, prioritising sovereign control over its crews and missions while drawing on international expertise to increase capability-building faster. As Gaganyaan mission moves forward and the Bhartiya Antariskh Station (BAS) takes shape, India can potentially propose medical harmonisation initiatives that help to build cross-jurisdictional medical practice regulations for multinational crews.

C. Liability and Attribution Ambiguities in Collaborative Missions Involving State and Private Actors

Human space travel is shifting from being run majorly by governments to missions where public agencies and private companies work together. In this new setup, figuring out who is responsible in case of medical problems arise has become a big challenge, mistakes in telemedicine, late diagnoses, or treatment decisions made during the mission don't have clear

[50] Claire A. O'Shea, *NASA Welcomes India as 27th Artemis Accords Signatory* (June 23, 2023).
[51] Malik, *supra* note 30.
[52] Simon Mansfield, *India's Gaganyatris Complete Initial Astronaut Training for ISRO-NASA Mission to ISS* (Dec. 2, 2024).
[53] *India-France Sign Agreement for Cooperation on Gaganyaan Mission*, The Hindu (Apr. 15, 2021)
[54] ISRO & ASA, *Implementing Arrangement for Gaganyaan.*
[55] Dimitrios Stroikos, *India's Space Policy: Between Strategic Autonomy and Alignment with the United States* (June 2, 2025).
[56] Sibu Kumar Tripathi, *First Pictures of ISRO's Bhartiya Antariksh Station Module Is Here* (Aug. 22, 2025).

rules about accountability[57]. Current international and national laws mainly deal with launch-related damage or agreements between parties, but they don't provide specific guidance for medical liability in these joint missions. India may face the problem of liability for acts not prohibited by international law as it does not have a domestic law to handle the consequences of its international and domestic obligations[58].

The 1967 Outer Space Treaty and the Liability Convention of 1972 (Liability Convention on International Liability for Damage Caused by Space Objects) still stand today as important international agreements. The State Parties "shall bear international responsibility for national activities in outer space, whether such activities are carried on by governmental agencies or by non-governmental agencies," according to Article VI of the Outer Space Treaty[59], which demands for the approval and ongoing oversight of private actors. Article VII[60] considers each launching state internationally liable for damage caused by its space object or component parts to another State party or its natural or juridical persons, on Earth, in the air, or in outer space. The Liability Convention elaborates these rules, Article II[61] imposes absolute liability for damage on Earth's surface or to aircraft in flight, while Article III[62] applies fault-based liability for damage elsewhere including to persons or property on board another space object. "Damage" is defined in Article I(a)[63] to include loss of life, personal injury or other impairment of health as well as property loss. These provisions were intended to govern state-to-state claims arising from collisions or re-entry incidents, rather than internal medical decisions made during flight.

The International Space Station (ISS) Intergovernmental Agreement (IGA) of 1998 provides a detailed operational model. Article 16[64] gives a cross-waiver of liability among partner states, United States, Russia, ESA member states, Japan and Canada and their related entities defined to include contractors, subcontractors, users, and customers at all tiers. Each Partner assumes

[57] Malik, *supra* note 30.
[58] C. Jayaraj, *India's Space Policy and Institutions, in Proceedings: United Nations/Republic of Korea Workshop on Space Law- United Nations Treaties on Outer Space: Actions at the National Level* 106.
[59] Outer Space Treaty, *supra* note 13, art. VI.
[60] Outer Space Treaty, *supra* note 13, art VII.
[61] Convention on International Liability for Damage Caused by Space Objects art. II, Mar. 29, 1972, 24 U.N.T.S. 187.
[62] *Id*. art. III.
[63] *Id*. art. I(a).
[64] Agreement Among the Government of Canada, Governments of Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America Concerning Cooperation on the Civil International Space Station art. 16, Jan. 29, 1998, T.I.A.S. No. 12927.

risks coming in ISS activities and agrees not to bring claims against other Partners or related entities for damage arising from "Protected Space Operations." The waiver is interpreted broadly and explicitly includes claims that might otherwise arise under the Liability Convention. Article 17[65] keeps the Liability Convention obligations in place, except where the cross-waiver changes them. Additional Memoranda of Understanding between space agencies help put these rules into practice. However, the Intergovernmental Agreement is specific to the ISS, focuses mainly on government-led missions and does not account for private medical service providers working outside the Partner chain[66].

Collaborative situations make the problem worse. For example, a private company could, for instance, send NASA or ESA astronauts with paying customers and give them telemedicine or medical kits. A government surgeon giving advice across different agencies, or a private doctor in charge of radiation exposure, creates overlapping responsibilities with no clear rules about who is to blame. These hypothetical situations show that there aren't any clear answers. Consider a hypothetical scenario, where a private lunar mission with people from all over the world, like the ones planned under the Artemis program. If there's a medical mistake, an onboard medical malpractice event, such as failure to treat decompression sickness properly, someone may file a claim. But who is responsible, the person running the mission, the company that made the medical software, or the country's space agency that provided guidance?

The gap of lack of proper legal provisions guiding space medicine persists because the core treaties were formed during the Cold War era. At that time the space activities were assumed to be exclusively state-driven. The commercial boom has arrived since 2010s seen by SpaceX's first crewed flights in 2020 and subsequent Axiom private missions to the ISS[67]. The Artemis Accords (2020) is a non-binding political understanding signed by over 50 nations. They differ questions of liability to future bilateral agreements (Section 2)[68], which must include provisions on liability but do not address medical issues specifically. These

[65] *Id*. art. 17.
[66] Agreement Among the Government of Canada, Governments of Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America Concerning Cooperation on the Civil International Space Station art. 16, Jan. 29, 1998, T.I.A.S. No. 12927, at 7.
[67] *Ethical Considerations for the Age of Non-Governmental Space Exploration* (June 11, 2024).
[68] The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes § 2 (Oct. 13, 2020).

accords affirm compliance with the Outer Space Treaty and Liability Convention yet provide no harmonised rules for hybrid medical responsibility.

The Gaganyaan human spaceflight program, run by ISRO, is working with partners like the Sree Chitra Tirunal Institute for Medical Sciences & Technology on space medicine research covering telemedicine, radiation biology, and astronaut health systems. Indian astronauts have also trained through private U.S missions such as Axiom-4 on SpaceX vehicles. But if a medical error happens, for example a misdiagnosis during telemedicine in microgravity by a private consultant or an international partner advising an Indian crew member it's unclear who would be held responsible. Private providers are covered by normal medical licensing and tort laws on Earth, but laws in space are not settled. Current liability waivers or cross-agreements are patchy[69], usually limited to launch phases or specific contracts, and don't clearly medical malpractice. Unlike ISS Agreement, which has broad liability, sharing rules, India's frameworks don't yet provide mission-specific protections for medical issues in mixed state- private crews.

India's lack of a full national space law has created gaps in handling medical liability[70]. Although the 2023 Space Policy and National Space Promotion and Authorisation Centre (NGP)[71] encourage private sector involvement and align with international treaty obligations, they don't clearly explain who is responsible in medical situations. The proposed Space Activities Bill is expected to bring clarity on liability, insurance, and private regulation but for now India relies only on guidelines, which leave many uncertainties. This makes private medical companies hesitant to join missions, exposes India to international claims under the Liability Convention since the launching state carries the main responsibility, and could lead to lawsuits being filed in different countries[72]. It also means protections are uneven. Government astronauts may be covered by their agencies, while private participants or partners face weaker safeguards. As India moves forward with Gaganyaan and aims to grow its share of the global space economy, the lack of clear medical liability rules in joint missions' risks crew safety, international cooperation, and private sector growth. India urgently needs bilateral agreements or domestic reforms that specifically address medical responsibility in space.

[69] Malik, *supra* note 30.
[70] Shrawani Shagun, *Why India Needs a National Space Law Urgently*, The Hindu (Aug. 21, 2025).
[71] Department of Space, Government of India, *Indian Space Policy 2023* (Apr. 20, 2023)
[72] Jayaraj, *supra* note 60.

D. Gaps in Insurance Coverage for Hidden Health Issues.

One of the biggest gaps in space governance is the lack of strong, standardised insurance or compensation systems for astronaut health after missions. The immediate mission safety protocols receive attention at the same time long term impacts including on health and related financial costs remain ignored[73]. The long-term human and financial costs of space travel, particularly latent diseases, may appear years or decades later. This leaves astronauts carrying personal risks without proper protection. It threatens the future of human space exploration by weakening trust, people hesitate to get involved, and both space agencies and private companies are left facing unclear responsibilities and risks.

Current rules for astronaut health are scattered and limited. In the United States, NASA's TREAT Astronauts Act (2017)[74] allows the agency to monitor, diagnose and treat medical and psychological conditions linked to spaceflight for former government astronauts and payload specialists. This builds on the Lifetime Surveillance of Astronaut Health (LSAH)[75] program at Johnson Space Centre, which already tracks astronaut health over time. The Act expands this into full medical services, annual exams, screenings, and treatment without astronauts having to share costs. LSAH itself works like an occupational health system, collecting long-term data on illness, death and risks from space exposure. This information helps guide astronaut care, develop countermeasures, and set standards for future missions.

On Earth, there are various similar models, like worker's compensation for radiation workers or health protections for pilots. But these don't fully capture the substantial risks of space[76], in which astronauts face multiple hazards at once. For private astronauts and commercial crews, protections are even weaker. In U.S. Companies usually require participants to sign liability waivers or cross-waivers under FAA rules, meaning they agree not to sue each other if

[73] Marcia Smith, *Witnesses Argue Government Has Ethical Obligation for Lifetime Astronaut Medical Care- And Needs Data, Too* (June 15, 2016).
[74] NASA, *TREAT Astronauts Act*.
[75] *The Lifetime Surveillance of Astronaut Health*, [NLSP] NLSP (last visited Apr. 12, 2026).
[76] NASA Transition Authorization Act of 2017, Pub. L. NO. 115-10, § 442(a)(1), 131 Stat. 14, (2017).

something goes wrong[77]. While personal or group insurance policies often rely on employer-provided coverage that excludes commercial spaceflight[78].

The absence of an international or standardised compensation model for post mission claims, particularly those involving long-latency conditions, is a major gap. Commercial space insurance markets exclude or severely limit "space risks", including radiation-induced illnesses that may manifest 10-20 years or more after exposure. International crew members on joint missions often fall between national systems, with coverage depending on the sponsoring agency rather than a unified framework. This leaves commercial participants, former astronauts from non-NASA programs, and crews from emerging spacefaring nations without reliable recourse.

Long-latency diseases take years to show up and are challenging for space travel. NASA's Human Research Program (HRP) reports points to galactic cosmic rays (GCR) high energy, high-linear energy transfer particles as a primary driver of degenerative effects beyond low-Earth orbit. These can cause long-term health problems. These can increase lifetime cancer risk (radiation carcinogenesis), central nervous system (CNS) degeneration leading to cognitive impairment or accelerated neurodegenerative disease, cardiovascular damage, and even speed up aging[79]. Living in microgravity worsens health with conditions like Spaceflight-Associated Neuro-ocular Syndrome (SANS)[80], ongoing heart and circulation problems, and muscle and bone changes whose long-term effects are still being studied. The 2014 report by the Institute of Medicine (IOM), Health Standards for Long Duration and Exploration Spaceflight, warned that these risks are not well understood and stressed that chronic, low-dose exposure to GCR in space is very different from radiation exposure on Earth[81].

Real world cases show the weakness of protections. In 2014, the Institute of Medicine (IOM) called for NASA that it has an ethical duty to provide with lifetime health care and monitoring

[77] 14 C.F. R. pt. 440 (2025).
[78] *Space Tourism and Denied Life Insurance Claims*, Space Tourism and Space Related Life Insurance Claims (Jan.5, 2025).
[79] Nathan Cranford & Jennifer Turner, *The Human Body in Space* (Feb. 2, 2021).
[80] NASA, *Risk of Spaceflight Associated Neuro-ocular Syndrome (SANS)*, Risk of Spaceflight Associated Neuro-ocular Syndrome (SANS) - NASA (last updated Mar. 16, 2025).
[81] Institute Of Medicine Report, *Health Standards for Long Duration and Exploration Spaceflight: Ethics Principles, Responsibilities, and Decision Framework*, Institute of Medicine Report: "Health Standards for Long Duration and Exploration Spaceflight: Ethics Principles, Responsibilities, and Decision Framework" and OCHMO Implementation Plan (Apr. 7, 2015).

to astronauts, since they take extraordinary risks[82]. But NASA's TREAT Act only covers U.S. government astronauts, leaving commercial participants and international partners without similar guarantees[83]. Insurance problems add another layer as life and health policies often exclude hazardous activities like space travel, and proving that radiation exposure caused cancer decades later is extremely difficult[84]. Without clear frameworks, claims could easily be rejected. Because of exclusions in insurance contracts, time limits on filing cases, or the challenge of linking a disease directly to spaceflight[85]. This leaves astronauts vulnerable and highlights the urgent need for dedicated rules to ensure fair coverage and accountability for everyone involved in human space missions.

These gaps exist because space law has stayed silent on astronaut health[86]. The 1967 Outer Space Treaty only talks about helping and returning astronauts right after missions, but says nothing about long-term care or compensation. The 1972 Liability Convention makes countries strictly liable for damage caused by space objects like harm to people or property on Earth or in aircraft. But it doesn't cover crew health problems from space exposure. Unlike the nuclear sector's Price Anderson Act[87] or international conventions, or aviation's Montreal Convention with its structured passenger liability regimes[88] space law lacks any dedicated compensation convention for latent astronaut injuries. Treaties prioritise state liability for hardware-related damage over individual occupational health protections, and no multilateral body has filled the void despite decades of calls from ethics experts and scientists, no international body has stepped in to create clear rules or compensation systems for astronaut medical issues[89].

IV. Pathways for Reform: Towards a Comprehensive Indian Space Health Law

India's Gaganyaan mission, led by ISRO, is designed for short trips in low-Earth orbit about three days at 400 km altitude with a crew of three. The focus so far has been on keeping

[82] *Health Standards for Long Duration and Exploration Spaceflight: Ethics Principles, Responsibilities, and Decision Framework* (Apr. 2014).
[83] Robert E. Lewis, *FAQs for the TREAT Astronauts Act* (Mar. 16, 2023).
[84] *Cosmic Radiation Deaths: Can Life Insurance Deny Space Claims?* (Aug. 17, 2025).
[85] *Cosmic Radiation Deaths*, *supra* note 86.
[86] Malik, *supra* note 30.
[87] Price-Anderson Act: Nuclear Power Industry Liability Limits and Compensation to the Public After Radioactive Releases, Price-Anderson Act: Nuclear Power Industry Liability Limits and Compensation to the Public After Radioactive Releases | Congress.gov | Library of Congress, (last visited Apr. 12, 2026).
[88] International Civil Aviation Organisation (ICAO), *International Air Travel Liability Limits Set to Increase, Enhancing Customer Compensation.*
[89] Malik, *supra* note 30.

astronauts safe during the mission. This includes health monitoring systems, life support, radiation protection (developed with DRDO), emergency medical kits, and recovery plans. ISRO is also working with institutions like the Institute of Aerospace Medicine and has signed new agreements to strengthen space medicine research. These efforts address immediate risks such as bone and muscle loss from microgravity, fluid shifts in the body, and short-term radiation exposure. However, there are still no clear public plans for dealing with long-term health problems after missions. Issues like radiation-induced cancer, heart disease, nervous system damage, or faster aging conditions that may appear years later remain underdeveloped or missing from India's current frameworks.

Astronaut protections in India appear ad hoc and mission specific. For example, when Indian astronaut, Shubhanshu Shukla. joined the Axiom-4 mission to the ISS, a commercial multilateral flight, he was covered by a very high-value accident insurance coverage potentially upwards of ₹200 crore as a part of ~$60 million package, covering training, launch, and immediate risks[90]. Similar policies, ranging from ₹40 to160 crore per person, have been mentioned for other high-risk space activities[91]. These policies mainly cover accidents during training, launch, and immediate mission risks. They are arranged by the government or through global insurers, but they usually don't cover long-term health problems like radiation-related cancers, which may appear decades later and are hard to prove. In India, commercial space insurance is still new, costly, and focused mostly on satellites and launch risks, such as liability for debris or failures. Experts point out that India lacks structured systems for risk-sharing, long-term coverage, or clear rules for astronaut health claims after missions. Private companies are advised to get insurance, but there is no standard model for protecting astronauts against long- term medical issues.

Implementing these would not only fulfil ethical responsibilities but strengthen India's position as a responsible spacefaring nation, attract skilled talent, encourage private companies to join, and protect the long-term health of astronauts who take these risks. As Gaganyaan and formation of a national space station marks deeper exploration, closing this gap is essential to ensure human costs do not outpace technological gains.

[90] Diksha Modi, *Shubhanshu Shukla's Space Insurance Could Be the Costliest in the World. Here's What It Covers,* News18 (July 2, 2025).
[91] Modi, *supra* note 90.

V. Conclusion

Current international frameworks, such as the Outer Space Treaty and Liability Convention, prioritise state responsibility for acute harms but neglect chronic astronaut health risks like radiation-induced carcinogenesis and microgravity-related degeneration. India's reliance on policies like the Indian Space Policy 2023 and lapsed Draft Space Activities Bill exacerbates four interlinked gaps: telemedicine licensing, cross-jurisdictional medical practice, liability attribution in state-private collaborations, and insurance for latent post-mission conditions.

Collectively, these discrepancies reveal a major disconnect between outdated space agreements and present-day circumstances. The treaties created during the Cold War, assumed short missions run only by states. But modern spaceflight involves private companies, multinational crews, and deep-space missions with long communication delays, challenges the current laws don’t address. The resulting legal gaps threatens mission safety, deters participation, hampers international cooperation under instruments like the expanding Artemis Accords, and risks losing critical long-term health data essential for both space sustainability and terrestrial medical benefits. Closing these gaps is essential if human expansion beyond Earth is to be fair, safe, and sustainable.

India can draw from global models: the ISS Intergovernmental Agreement's cross-waivers offer a blueprint for hybrid liability; Canada's Health Beyond Initiative demonstrates post-mission surveillance; and EU GDPR-aligned ESA protocols ensure data harmonisation. Unlike these, India lacks statutory equivalents, leaving Gaganyaan and Bharatiya Antariksh Station (BAS) vulnerable.

India must enact a Space Health Act to:(i) establish extraterritorial telemedicine licences via ISRO and National Medical Commission integration; (ii) mandate unified medical standards for multinational crews, aligned with Artemis Accords; (iii) clarify liability through mandatory insurance pools for latency diseases; and (iv) create an Astronaut Health Authority under IN-SPACe for oversight. These measures would safeguard strategic autonomy, foster academia-industry ties (e.g., IAM-SCTIMST), and position India as a leader in equitable deep-space exploration.

In conclusion, bridging these gaps transforms space medicine from an operational afterthought to a robust legal pillar, ensuring mission success, astronaut well-being, and sustainable human expansion beyond Earth orbit.