Telemedicine and Healthcare Access for Space Miners: Building Social Policy in Outer Space

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Abstract

The development of the space industry and the implementation of commercial projects for resource extraction in outer space create a new platform for discussion. Space mining is a widely-debated topic, and the day is not far off when, in addition to deploying robots for resource extraction, it will be necessary to send workers, particularly space miners, to effectively operate equipment and manage robotic systems. This creates health risks and challenges in access to medical care, similar to those faced by astronauts who are trained to provide basic medical assistance. This study examines how telemedicine technologies must evolve to serve these isolated worker groups, where communication delays, limited resources, and extreme environmental conditions fundamentally change the healthcare delivery paradigm. Considering the growing role of the private sector in managing space resources, there is a need to revise social policy, particularly its application in extraterrestrial conditions. The study proposes comprehensive policy reforms aimed at overcoming technological limitations and addressing gaps in the legal and regulatory framework governing space medicine. Sustainable space resource extraction operations require the development of effective social policies that guarantee comprehensive universal medical coverage, mental health support, and emergency evacuation protocols for all workers at extraterrestrial facilities. The study

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concludes that an ethical space economy is impossible without the creation of healthcare systems that protect workers' dignity and ensure sustainable industrial development beyond Earth.

Keywords: telemedicine, healthcare access, space mining, social policy, space law, health law, human rights, occupational health, outer space governance

Telemedicina y acceso a la atención médica para mineros espaciales: construcción de políticas sociales en el espacio exterior

Resumen

El desarrollo de la industria espacial y la implementación de proyectos comerciales para la extracción de recursos en el espacio exterior crean un nuevo foro de debate. La minería espacial es un tema ampliamente debatido, y está cerca el día en que, además de desplegar robots para la extracción de recursos, será necesario enviar trabajadores, en particular mineros espaciales, para operar eficazmente los equipos y gestionar los sistemas robóticos. Esto genera riesgos para la salud y dificultades en el acceso a la atención médica, similares a las que enfrentan los astronautas entrenados para brindar asistencia médica básica. Este estudio examina cómo deben evolucionar las tecnologías de telemedicina para atender a estos grupos de trabajadores aislados, donde las demoras en las comunicaciones, los recursos limitados y las condiciones ambientales extremas transforman fundamentalmente el paradigma de la prestación de servicios de salud. Considerando el creciente papel del sector privado en la gestión de los recursos espaciales, es necesario revisar las políticas sociales, en particular su aplicación en condiciones extraterrestres. El estudio propone reformas políticas integrales destinadas a superar las limitaciones tecnológicas y abordar las deficiencias en el marco legal y regulatorio que rige la medicina espacial. Las operaciones sostenibles de extracción de recursos espaciales requieren el desarrollo de políticas sociales efectivas que garanticen una cobertura médica universal integral, apoyo a la salud mental y protocolos de evacuación de emergencia para todos los trabajadores en instalaciones extraterrestres. El estudio concluye que una economía espacial ética es imposible sin la creación de sistemas de salud que protejan la dignidad de los trabajadores y garanticen un desarrollo industrial sostenible más allá de la Tierra.

Palabras clave: Telemedicina, acceso a la atención sanitaria, minería espacial, política social, derecho espacial, derecho sanitario, derechos humanos, salud ocupacional, gobernanza del espacio exterior.

太空矿工的远程医疗和医疗保健服务：构建外太空社会政策

摘要

航天工业的发展和外太空资源开采商业项目的实施，为相关讨论开辟了新的平台。太空采矿是一个备受争议的话题，不久的将来，除了部署资源开采机器人外，还需要派遣工作人员（特别是太空矿工）来有效操作设备和管理机器人系统。这将带来健康风险和医疗服务获取方面的挑战，类似于接受过基础医疗培训的宇航员所面临的挑战。本研究探讨了远程医疗技术应如何发展才能更好地服务于这些与世隔绝的工作人员群体，因为通信延迟、资源有限和极端环境条件从根本上改变了医疗服务的模式。考虑到私营部门在太空资源管理中日益重要的作用，有必要修订社会政策，尤其是在外太空环境下的政策应用。本研究提出了一系列全面的政策改革方案，旨在克服技术限制，并弥补太空医学法律法规框架中的不足。可持续的太空资源开采作业需要制定有效的社会政策，以保障所有在外太空设施工作的人员享有全面的全民医疗保障、心理健康支持和紧急撤离方案。该研究得出结论：若不建立能够保护工人尊严并确保地球以外可持续工业发展的医疗保健体系，就不可能实现合乎伦理的太空经济。

关键词：远程医疗，医疗保健服务，太空采矿，社会政策，太空法，卫生法，人权，职业健康，外层空间治理

Introduction

We are on the threshold of a new era. Resource extraction from outer space has turned from science fiction into a real possibility. Organizations such as SpaceX, Blue Origin, and Planetary Resources are rapidly developing technologies for collecting materials from asteroids and the Moon (Kendal et al., 2025; Fleming et al., 2023; Cilliers et al., 2023; Zwart et al, 2023; Sharma and Mitra, 2024). Although the initial strategies focus on automated systems (Tashtoush et al, 2019; Obosu and Frimpong, 2025; Rogers et al, 2019; Campa et al., 2019), the complex nature of these missions will eventually require human involvement or space miners. These workers will live and work in the most remote workplaces that humanity has ever created.

In our opinion, these workers will face health hazards that make even the most isolated jobs on Earth seem easily accessible. We expect space miners to become industrial workers who will be sent to work with equipment and control robotic systems (Rogers et al, 2019; Eurofound, 2024; Obosu and Frimpong, 2025; Tashtoush et al, 2019). As space workers, they will experience the same physiological problems as astronauts, including radiation exposure, deterioration of bone density and weakening of the cardiovascular system (Goto, 2025; Demontis, 2017; Garett-Bakelmann et al., 2019; Roy-O'Reilly, 2021), but they will not have the opportunity for rapid evacuation.

The main purpose of this study is to draw attention to the prospects of the future of space mining and to the problem of social policy and access to healthcare for future space miners. This study is a futuristic approach through the lens of current technologies such as telemedicine and telehealth. The study employs a conceptual literature review approach. Claud AI was used as a tool for editing. The main limitation of this study is the inability to study both the health status of future space miners and the use of the proposed technologies.

Findings

The study revealed that telemedicine originated with NASA's development of remote health monitoring systems for astronauts in the 1960s. The application of telemedicine in the modern world also involves overcoming long and insurmountable distances and also includes an inclusive approach to diagnosing patients facing problems with access to healthcare (Kim, 2004; Stoltzfus et al., 2023; Haleem et al, 2021). However, as we approach the era of commercial space flight, we are going to face a health crisis that existing systems cannot resolve.

In our opinion, space miners will work in conditions where communication with Earth can be interrupted for up to 40 minutes in each direction during flights to Mars, with severe restrictions on the supply of medicines, the lack of opportunities for rapid evacuation and severe psychological pressure due to complete isolation in conditions where there is an emergency in the field (Parisi et al, 2023). This can be fatal. None of the existing terrestrial healthcare systems can handle these extraordinary circumstances, regardless of whether we consider the Nordic model of social security and welfare, the American employer-based system, or some alternative approach (Boushey and Tilly, 2008; Barnes et al; 2021; Pedersen and Kuhnle, 2017). We have to develop completely new solutions from scratch. Our research has identified three critical gaps that need to be addressed in ensuring access to healthcare and medical services for space miners. These are technological, political, legal, and ethical gaps.

When talking about technological gaps, keep in mind that we need autonomous diagnostic systems that can operate independently when communication with Earth is impossible. It is necessary to create treatment algorithms based on artificial intelligence that will help space miners perform complex medical procedures. Medical workers need special training to work in space conditions so that they can provide remote assistance in extreme circumstances (Kuwaiti et al., 2023; Waisberg et al., 2022; Kuhail et al., 2025).

Talking about the social policy gap it is necessary to say that current social policies assume proximity to healthcare infrastructure. Space miners will need comprehensive medical care that transcends national borders and corporate interests. Mental health support systems must be designed with unprecedented levels of isolation in mind. Emergency evacuation protocols should take into account travel time measured in months, not hours (Pagel and Choukèr, 2016).

The last gap, in our opinion, as already mentioned, is the legal and ethical gaps. Space legislation currently does not provide any framework for the provision of medical care to commercial workers in the space industry. When private companies send employees to conditions where traditional medical care is not possible, the issue of liability will remain unresolved (Günel, 2022; Kendal et al, 2025). We must identify methods to protect the dignity of workers in situations where the absence of emergency medical care could endanger the entire flight.

Conclusion

The space mining industry is developing rapidly, but our social policy is lagging behind. We have very few opportunities to develop ethical standards before starting commercial activities. Politicians, international organizations and leaders of the space industry must urgently take measures to address these problems, while there is still time to form a responsible framework for the future. We must ensure that as humanity reaches for the stars, we don't leave behind our commitment to human dignity and universal healthcare access. The development of space exploration depends not only on technological advances, but equally on our commitment to protecting the workers who will contribute to these advances.

This is not just about technology or politics. It's about basic human values and dignity. By exploring space, we cannot abandon the social progress achieved on Earth. Creating a just and ethical space economy requires healthcare systems that genuinely protect workers and prioritize their physical and mental wellbeing. We're not just talking about space miners. The framework we develop will apply to lunar bases, Mars colonies, and any future human expansion beyond Earth. The decisions we make today about access to healthcare in space will determine the future of human civilization beyond our planet.

To achieve the set goals, we propose a comprehensive policy framework built on three pillars:

Technological Innovation: Investments in autonomous medical systems, AI-driven diagnostics, and advanced telemedicine protocols specifically designed for space environments. We are talking not only about more advanced technologies, but also about rethinking the provision of healthcare in conditions where traditional assumptions are not applicable.

Social Policy Reform: Development of universal healthcare standards that transcend terrestrial boundaries. This includes mandatory comprehensive medical coverage, mental health support systems, and emergency care protocols that address the unique challenges of space work.

International Cooperation: These challenges cannot be solved by any country or corporation acting independently. We need international standards for space healthcare that prioritize worker protection over corporate profits. This requires new forms of global governance for space commerce.

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