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## Biological and social challenges of human reproduction in a long-term Mars base

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### ABSTRACT

A manned mission to Mars and the establishment of the first human settlement in outer space was once a mere figment of science fiction but is now being planned and expected to take place in the following twenty years. Mars is under consideration as the next planet beyond Earth to support continuous human exploration. Unfortunately, such an endeavor comes with titanic challenges in various disciplines, from space travel technology to medical, biological, social and ethical challenges. Reproduction involves many aspects of human life, and is also the subject of various disciplines. We assume that human reproduction in a Mars settlement will be necessary for the long-term success of an outer space mission. Thus, here we explore and discuss the challenges involving the likely scenario of human reproduction in Mars. To anticipate the many issues associated with human reproduction outside Earth, we applied multidisciplinary approaches to discuss possible social, ethical, medical and biological challenges of human reproduction on Mars.

### 1. Introduction

The idea of a manned mission to Mars is becoming actualized by both governmental and private enterprises and may become a reality in the next 20 years. Motivations behind deep-space missions include the search for natural resources, the expansion of the human civilization (Impey, 2015), and the search for other forms of life (National Aeronautics & Space Administration n. d.). These motivations are closely related to environmental, economic and social issues taking place on Earth, notably the dispute for land and other territories (Shelhamer, 2017). An analysis of the planning of a manned mission to Mars may consider short-term and/or long-term perspectives. In our paper, we focus on a long-term mission that will include building a stable human settlement on Mars. For obvious technological and medical reasons, such a stable settlement will likely be achieved long after the first team of astronauts land successfully on Mars. If the mission planners decide at some point in the future to settle on Mars, reproduction will be necessary to enable the long subsistence of such a community. We assume that current plans of manned missions to Mars will necessarily result in the establishment of a human colony on Mars, regardless of the many required technological advances yet to be made. Therefore, it is

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worth discussing and predicting cultural, social and biological challenges that may appear on a future Martian colony (Szocik, 2016). As pointed out by our group and others, establishing a Martian outpost is likely to bring many of the same societal problems we face on Earth (Nature, 2016). Such problems include all the axiology which defines the life of people living in a colony (Becker, 2016; Lipiec, 2016).

Space exploration is constantly increasing in popularity. So far, governmental institutions such as NASA, Roscosmos State Corporation, China National Space Administration, the European Space Agency and private companies such as MarsOne, Blue Origin or SpaceX are actively involved in sending human astronauts to Mars. The technological advances to be achieved in the next decades to successfully establish the means for Mars exploration are expected to boost several sectors of the global economy and change society. Stephen Hawking once stated, “I believe that the long-term future of the human race must be space and that it represents an important life insurance for our future survival, as it could prevent the disappearance of humanity by colonizing other planets” (Hawking, 2015). There is no doubt that humans as a species face significant challenges for their own survival on Earth. Overpopulation, war, climate change and the shortage of essential resources such as water, comprise a threatening but plausible reality for the next decades. Although space exploration will result in human progress and in a reassessment of our values and priorities, we must not use space exploration as an excuse to neglect our home planet.

Organizations involved in space travel so far have envisioned different strategies to reach Mars. SpaceX is planning a “one-way ticket” journey for their first astronauts, similar to the mission plan in development by Mars One (Sydney, Owens, Ho, Schreiner, & de Weck, 2016, p. 192). Conversely, NASA is planning a return trip for the astronauts, which poses an incredible technical challenge. NASA’s solution is the Mars Ascent Vehicle (MAV), which will be sent to Mars a few years before the astronauts so that they have the means to return to Earth (National Aeronautics & Space Administration, 2012). Nonetheless, human reproduction on Mars, or during the journey to Mars, will eventually take place. We should anticipate the challenges associated with such an important aspect of human life.

Human reproduction combines medical, biological, social and cultural aspects. In this paper, we will discuss the main challenges of human reproduction on a future Mars colony. We consider that the logistics of human reproduction should be carefully determined to conciliate resources and colony growth on Mars. The central issues are how a Martian colony should maintain a balance between reproductive rights and the need for reproduction in the inhospitable Martian environment. Also, little is known about pregnancy in outer space. We discuss possible answers for the following questions: how could we ensure the success of human reproduction? Could we sustain continuous human generations in a Mars colony? How (if any) will these biological and medical challenges affect our moral thinking and moral intuitions?

## 2. Human reproduction in Mars is necessary for long-term base establishment

The predicted organization of a Martian colony, as well as current knowledge on human population dynamics, suggests that reproduction on Mars will be necessary for colony survival and subsequent expansion. Until a Martian colony is established as a self-sustainable population, immigration from Earth will also be necessary, but eventually should become complementary. Chris Impey and colleagues have calculated that a minimum viable human population for an extra-terrestrial colony to survive throughout time should include about 5000 individuals (Impey, 2015). This calculation considers possible and unpredictable catastrophes, illnesses and other demographically deleterious phenomena. Other calculations estimate a minimal viable population (MVP) of a given vertebrate species to be 5816 adult individuals (Reed, O’Grady, Brook, Ballou, Frankham, 2003, p. 23), or approximate numbers (Flather, Hayward, Beissinger, & Stephens, 2011). Such calculations refer to ecological studies on Earth, but consider all possible extinction events. We suppose that in the extreme Martian environment the estimated human MVP is required to be greater.

It is very unlikely that a human colony on Mars would reach as many individuals in the decades following the first missions, although large-scale transportation to Mars is being conceived. Journeys to Mars, such as in Elon Musk’ SpaceX Interplanetary Transport System, are expected to take 7–9 months, will be extremely costly, dangerous and will only be able to take a few astronauts at first. More importantly, it is unknown how many people would be willing to live permanently on Mars. We believe that humans born and raised on Mars will be better adapted psychologically and physiologically to life in the planet, and will be willing to accept ideologies, training and the culture of an extra-terrestrial colony. Therefore, we consider human reproduction on Mars to be an important means for the establishment of an enduring human community in Mars.

## 3. Social and ethical challenges of reproduction in Mars

The concept of reproduction on a Mars colony is challenging. Before we consider medical and biological objections, we must enumerate selected ethical and moral issues that are strictly correlated with sexual policy and regulation of fertility rate. Human history provides examples of control and regulation of human reproduction. Ethical and legal systems, both secular and religious, include rules for dating, mating/sex, and reproduction. Human sexuality and reproduction were and still are a fierce matter of debate on Earth. Below we discuss four challenging topics, describing how these issues have been treated on Earth and how they may be raised in the Martian context:

1. Value of human life
2. Abortion policy
3. The problem of value – Mars as a place beyond moral values
4. Sexual selection and artificial genetic engineering.

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