

The Willingness of Humans to Settle on Mars and the Factors that Affect It

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ABSTRACT

The willingness of humans to go to Mars is one of the most important facets of a successful human colony on Martian soil and is also arguably the most neglected since even if all the technological and logistical issues of the mission were to be perfected, it would be meaningless if no one were willing to go to Mars. The aim of this study is to study people's willingness to go to Mars, and the factors that affect it most, both positively and negatively. A pre-post study design with a survey was used for the primary data collection and analysed both quantitatively and qualitatively to derive conclusions from a total sample of 93 respondents. The results showed that the factors that most affected humans' willingness to settle on Mars were the advancement of research and innovation and the impacts on their body as a result of radiation and microgravity, closely followed by quality of life. The findings of this research study can be utilised by firms or even states in the future to determine how to promote their Mars missions, even if they do not involve settlements.

Introduction

In recent years, Mars has become an increasingly popular topic of discussion due to the research-based missions, such as the Curiosity rover, the Mangalyaan probe, and SpaceX's endeavours and ambitions. Alongside this rising interest, the possibility of a human settlement on Martian soil is coming closer and closer to becoming a reality with new reusable rockets bringing down costs and increasing amounts of data being received from rovers on Mars. However, a human settlement on Mars is not a simple activity; there are myriad factors that must be perfected.

NASA and Chinese rovers on Mars have provided humanity with data which has exponentially increased its knowledge of not only Mars and the solar system, but the universe. The most powerful rover ever sent to Mars, the Curiosity rover that landed on Mars in 2012, has shown that Mars could have indeed supported life forms in the distant past, due to it having found signs of the presence of water (NASA, n.d.). Further, India's space agency, ISRO, has also had amazing innovation in recent times, aiming for and achieving the most cost-efficient missions (Singh, 2019) in global space exploration, which is of paramount importance as funding is one of the biggest problems of space exploration - however, this problem may be resolved by reusable rockets.

The advent of reusable rockets (Falcon 9) from the prominent private organisation SpaceX has caused major changes to the space exploration industry by 78 successfully re-flown rockets and 100 successful landings from a total of 138 launches (SpaceX, n.d.), along with several of their other innovations and inventions, such as the Dragon capsule which was the first of its kind to dock on the International Space Station. To make human travel to Mars possible, the Starship project by SpaceX is the next big step in space exploration, and is SpaceX's current focus (SpaceX, n.d.). It is supposed to be capable of being entirely reusable and powerful enough to carry humans and cargo alike to Mars, and even further destinations in the solar system. Starship refers to the spacecraft and the Super Heavy rocket being used to launch it, combined, and is meant to be able to carry over 100 tonnes of weight, multiple times between Mars and Earth (SpaceX, n.d.). Another private spacefaring organisation, Blue Origin has been concentrating on the new space tourism industry, with Jeff Bezos' 'balloon' recently carrying humans to the edge of the atmosphere in luxurious fashion (Blue Origin, n.d.).

However, an extremely crucial factor of a human settlement on Mars, is the willingness of humans to go there and the factors that affect this. Discussion about this is almost completely missing in relevant literature, due to the disproportionate focus on the technical aspects of the endeavour. Through this study it was found that the factors that mostly affect respondents' willingness to go to Mars are the advancement of research and innovation and the impacts on their body due to radiation and microgravity. This aspect could be used to improve the public perception of such a mission, the funding private individuals would provide and most importantly, the availability of humans who are willing to go and inhabit the Martian settlement.

Description of Research Study

Research Aim

The research aim of this study was to explore and analyse how important certain chosen factors are in encouraging or discouraging respondents' willingness to settle on Mars.

Research Design

A pre-post study design was used for the research study, as the same questions were posed to the respondents before and after they were shown two videos on the research topic, to increase their knowledge about the topic, thus improving their capacity to answer the survey.

Consent and Ethical Issues

All ethical considerations were followed for this study. To maintain the highest privacy possible for this study, the respondents' names, email, or any other detail that could be used to identify them was asked in the survey; only their gender and age were collected. Informed consent was taken from respondents for data collection. Confidentiality and privacy of the respondents were maintained; no data would be disclosed to a third party. No identifiers such as name or pictures were disclosed in the article or while conducting the study. Ethical guidelines of research were followed.

Sample

The sample size taken for the survey conducted was 93 respondents out of which 64 were males and 28 were females, with 1 respondent preferring not to disclose their gender, and of myriad age groups (the average age bracket was 36-50 years old), however, the respondents primarily belonged to metropolitan areas in Maharashtra or Delhi, India.

Tools Used

For the online survey used to collect the data for this research study, the Google Forms me software was employed. The questionnaire contained 17 close-ended questions, regarding their age, gender, knowledge about the topic and their rating of the factors that could either encourage or discourage them from settling on Mars.

Data Collection

The primary data collected for this research study was conducted in an online Google Forms survey. The respondents were provided with videos to be watched for them to have enough knowledge regarding the topic and to understand the later mentioned factors, and then were asked to rate the importance of given factors in encouraging

or discouraging them from living on a Martian settlement. They were also asked to type in the first thoughts that came into their head when they saw the words “human life on Mars”.

Data Analysis

Two paired t-tests, two ANOVAs and thematic analysis was conducted to analyse the received data from the survey. The t-tests were used to see whether the provided videos made a significant difference to the knowledge and perspective of the respondents. The ANOVAs provided insight into which of the factors were most important, as well as other vital information regarding the factors. Lastly, the thematic analysis shows the main groups of thought regarding the topic, which was a wide range.

Results and Discussion

The study was aimed to analyse the results of the survey in conjunction with relevant literature in order to obtain the most key factors that affect the willingness of people to settle on Mars. The present study looks at the willingness of respondents to settle on Mars and the factors that encourage or discourage them.

There were two groups of factors chosen for the purpose of this study: encouraging factors and discouraging factors. The encouraging factors chosen after an exhaustive literature review were ‘Being the First to Settle on Mars’, ‘Advancing Research and Innovation’, ‘Survival Concerns’ and ‘Economic Interests’. Meanwhile, the discouraging factors chosen were ‘Impacts on Body due to Radiation and Microgravity’, ‘Bio-modifications’, ‘Emotional Isolation’, ‘Climate Conditions’ and ‘Quality of Life’.

Table 1 depicts the descriptive statistics of the encouraging factors show that advancing research and innovation ($M=4.27$, $SD=1.73$) had the greatest encouraging effect on the respondents’ willingness to settle on Mars, followed by survival concerns ($M=3.57$, $SD=1.78$), closely followed by economic interests ($M=3.32$, $SD=1.82$) and finally being the first to settle on Mars ($M=2.94$, $SD=1.86$). It is evident that advancing research and innovation have the highest mean level of importance by some distance, of the encouraging factors considered.

Table 1: Descriptive statistics of the encouraging factors (N=93)

	First to settle on Mars	Advancing research	Survival concerns	Economic interests
Mean	2.94	4.27	3.57	3.32
Median	2	4	4	3
Mode	1	5	4	1
Standard Deviation	1.86	1.73	1.78	1.822
Standard Error	0.19	0.18	0.18	0.19

The descriptive statistics show that the effects of radiation and microgravity ($M = 5.75$, $SD = 1.31$) is the factor that is the most discouraging to Indian respondents considering living on a Martian settlement. However, this means falls significantly to $M = 4.43$, $SD = 1.70$ when respondents are offered bio-modifications to combat the effects of radiation and microgravity, making it the least discouraging factor that was evaluated. This is extremely

closely followed by the quality of life ($M = 5.73, SD = 1.55$), with a negligible difference between their means; further, considering the additional question of bio-modifications, this would become the most discouraging factor that was assessed. Emotional isolation ($M = 5.34, SD = 1.56$) and climatic conditions ($M = 5.34, SD = 1.58$) are not at much of a distance, both having means over '5', being very discouraging (Table 2).

Table 2: Descriptive statistics of the discouraging factors (N=93)

	Radiation and microgravity	Bio-Modifications	Emotional isolation	Climate conditions	Quality of life
Mean	5.75	4.43	5.34	5.23	5.73
Median	6	4	5	5	6
Mode	7	4	7	5	7
Standard Deviation	1.31	1.70	1.56	1.58	1.55

The distribution of the respondents' ratings on each of the four encouraging factors was further examined and compared (figures 1-4). The encouragement provided by the possibility of advancing research and innovation (figure 2) is higher than the rest, with nearly 50% of people rating it a '5' or higher. Similarly, the encouragement provided by the possibility of being the first to settle on Mars (figure 1) is extremely low to most of the respondents, with 54% voting to be a '2' or lower. Economic interests were also not very encouraging to a large section of the respondents, since approximately 40% voted it to be a '2' or lower.

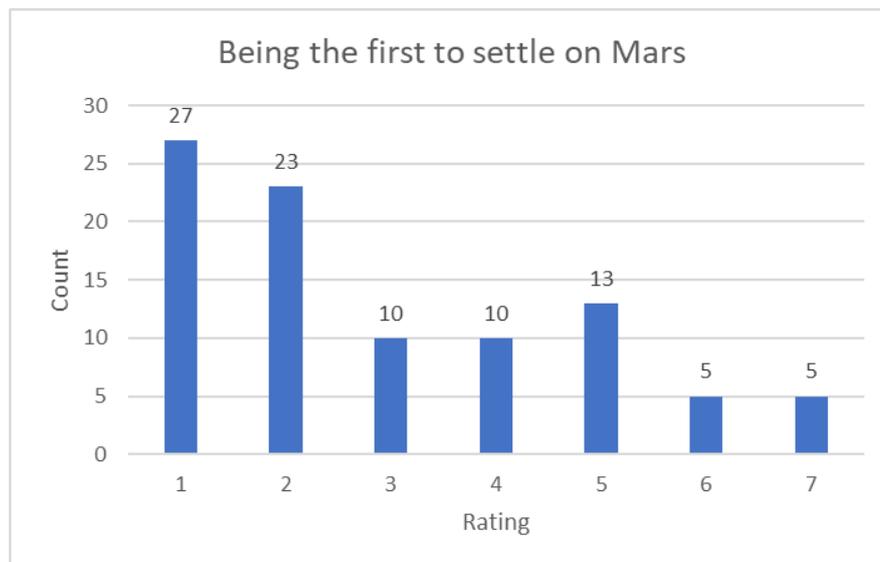


Figure 1: Respondents' ratings on how important Being the First to Settle on Mars is to their willingness to settle on Mars

Figure 1 denotes the respondents rated the importance of Being the First to Settle on Mars on a scale of 1 to 7 with 7 signifying paramount importance. Out of 93, 27 respondents gave it a rating of 1 and 23 gave it a rating of 2, which shows that most respondents consider it to be almost entirely unimportant. Meanwhile, only 5 respondents gave it a rating of 7, showing that very few people consider it to be extremely important.

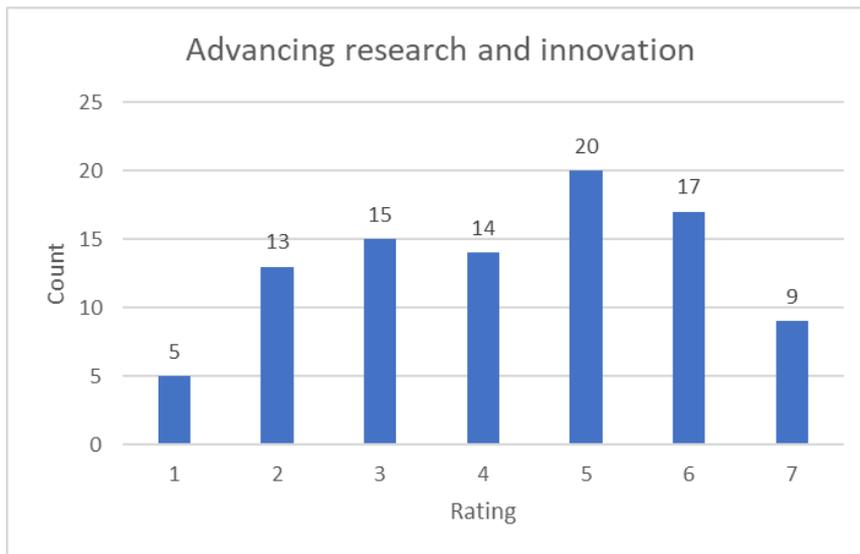


Figure 2: Respondents' ratings on how important Advancing Research and Innovation is to their willingness to settle on Mars

The respondents rated the importance of Advancing Research and Innovation on a scale of 1 to 7 with 7 signifying paramount importance. 20 respondents rated it a 5 and 17 rated it a 6, which indicates that a lot of respondents consider it to be quite important in determining their decision. However, only 5 people rated it a 1, which shows that there are very few people who consider the advancement of research to be wholly unimportant (Figure 2).

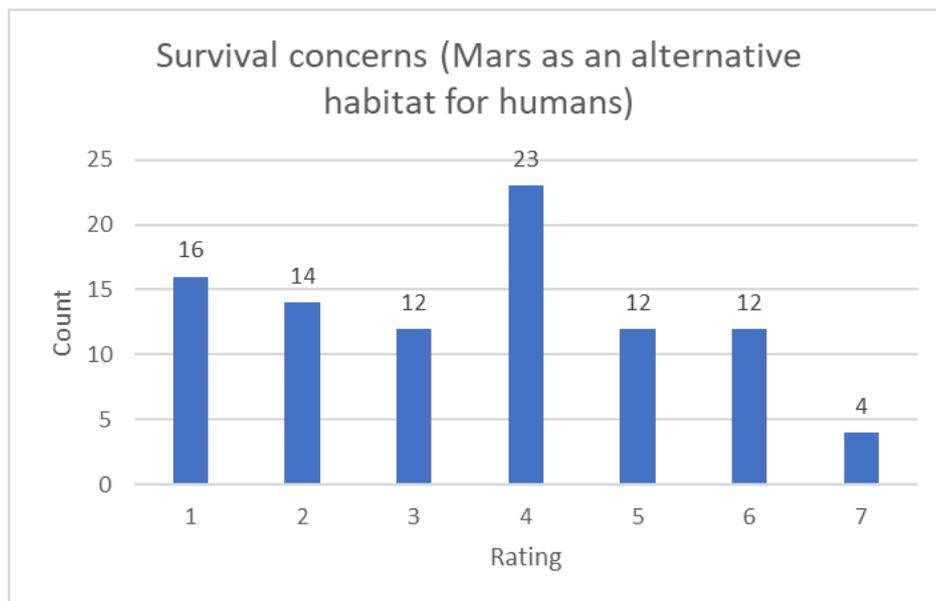


Figure 3: Respondents' ratings on how important Survival Concerns are to their willingness to settle on Mars

Figure 3 depicts the respondents rated the importance of Survival Concerns on a scale of 1 to 7 with 7 signifying paramount importance. 23 respondents voted it a 4 which shows that many respondents consider it to be a fairly important factor in determining their decision, while 16 respondents voted it to be a 1 which indicates that a substantial number of respondents also consider Survival Concerns to be of no importance in making their decision. However, only 4 respondents rated it a 7, which shows that extremely few people consider Survival Concerns as a paramount importance.

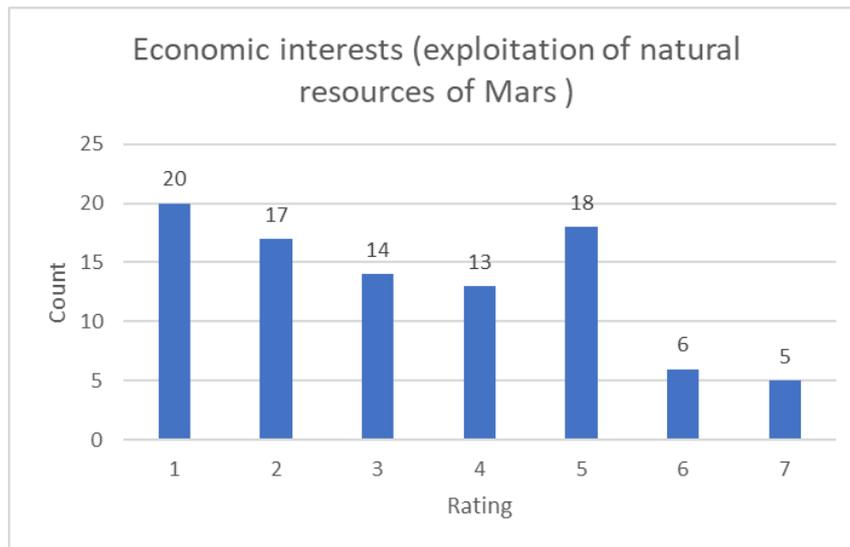


Figure 4: Respondents’ ratings on how important Economic Interests are to their willingness to settle on Mars

The respondents rated the importance of Economic Interests on a scale of 1 to 7 with 7 signifying paramount importance. 20 respondents rated it to be a 1, which indicates that a large number of respondents consider it to be of no importance to their decision. However, 18 respondents rated it to be a 5, meaning that several respondents also consider it to be quite important when making their decision. However, only 5 respondents rated it to be a 7, indicating that hardly any respondents consider it to be of paramount importance to their decision-making process (Figure 4).

The distribution of the respondents’ ratings on each of the four discouraging factors was further examined and compared (see figures 5-9).

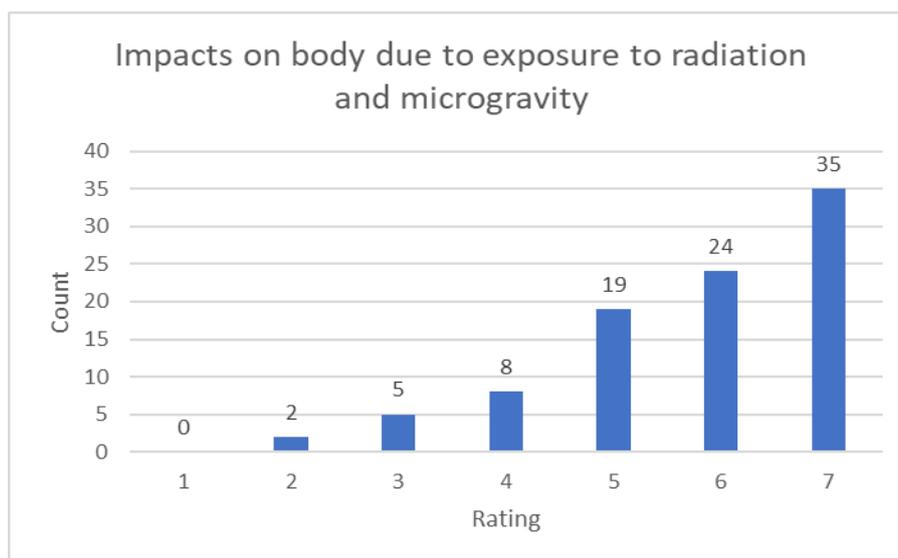


Figure 5: Respondents’ ratings on how important the Impacts on their Body due to exposure to Radiation and Microgravity are to their willingness to settle on Mars

The respondents rated the importance of the Impacts on their Body due to exposure to Radiation and Microgravity on a scale of 1 to 7 with 7 signifying paramount importance. 35 respondents rated it a 7 and 24 people rated it a 6, which shows that most respondents consider it to be extremely important to their decision. Interestingly, no respondents rated it a 1, which clearly means that all respondents think it holds some degree of importance (Figure 5).

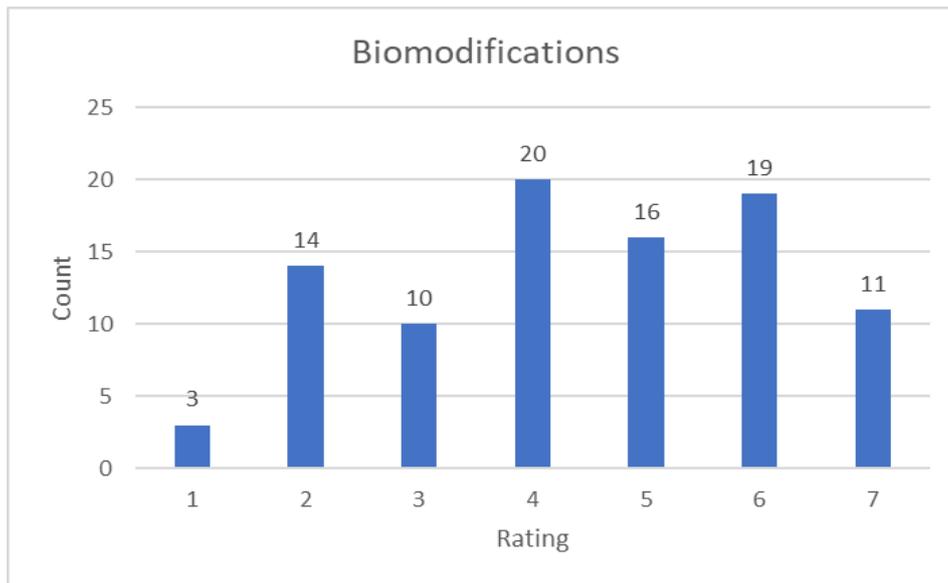


Figure 6: Respondents' ratings on how important Bio-modifications are to their willingness to settle on Mars

Figure 6 denotes that the respondents rated the importance of Bio-modifications on a scale of 1 to 7 with 7 signifying paramount importance. 20 of the respondents rated it a 4, which shows that a significant number of respondents considered it to be fairly important, along with 19 respondents rating it a 6 which signifies that they consider it very highly when making their decision. Meanwhile, only 3 respondents considered it to hold almost no importance, which indicates that nearly all respondents considered it to be important to a certain extent.

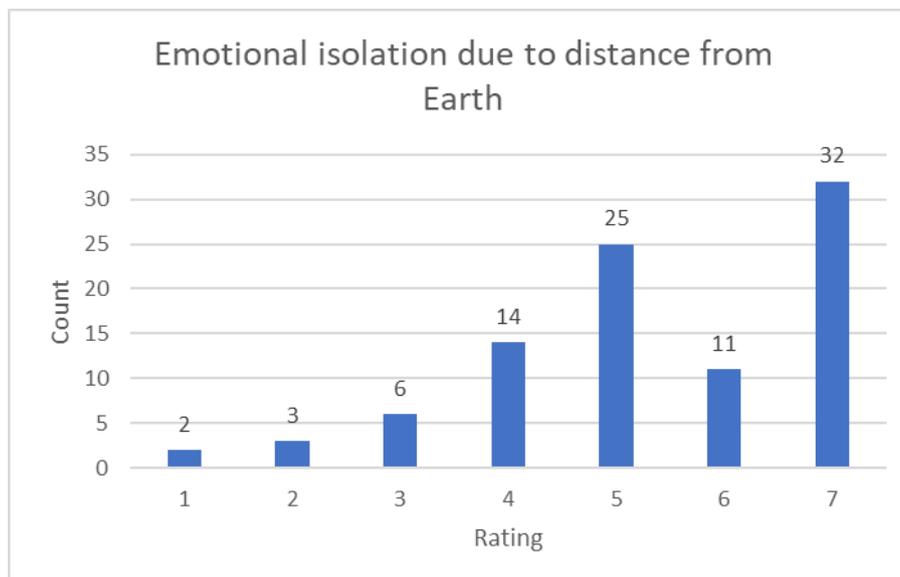


Figure 7: Respondents' ratings on how important Emotional Isolation is to their willingness to settle on Mars

The respondents rated the importance of Emotional Isolation on a scale of 1 to 7 with 7 signifying paramount importance. 32, over a third of all respondents, rated it a 7 which means that an exceptionally large portion of the respondents considered emotional isolation to be of paramount importance in their decision. 25 respondents also rated it to be a 5, which shows that another sizeable portion of the respondents consider it to be quite important in their deliberation. A mere 2 respondents rated 1, which means almost no respondents consider it to have no importance (Figure 7).

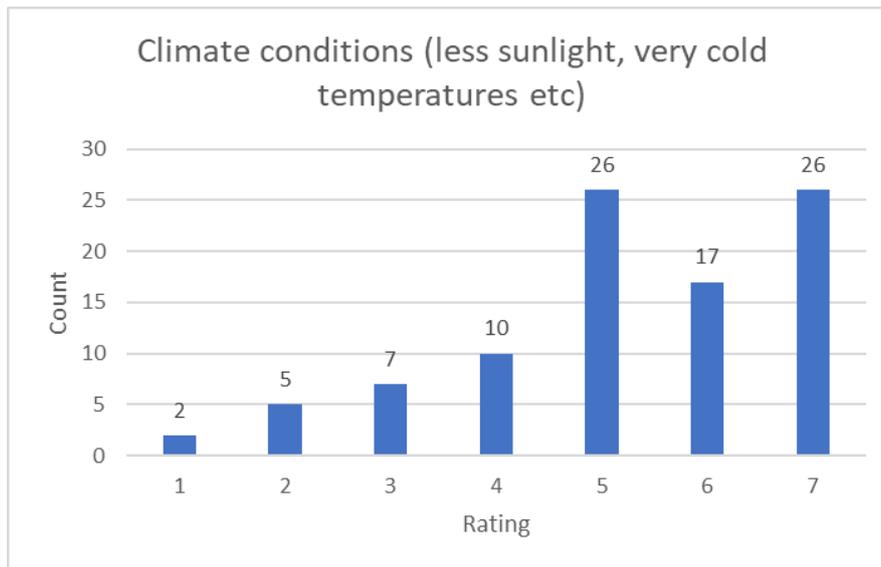


Figure 8: Respondents' ratings on how important Climate Conditions are to their willingness to settle on Mars

The respondents rated the importance of Climate Conditions on a scale of 1 to 7 with 7 signifying paramount importance. 26 people each rated it to be a 5 and a 7, which indicates that a large and equal number of people consider it to be quite important and of paramount importance. Just 2 respondents voted it to be a 1, signifying that extremely few respondents consider it to be completely unimportant (Figure 8).

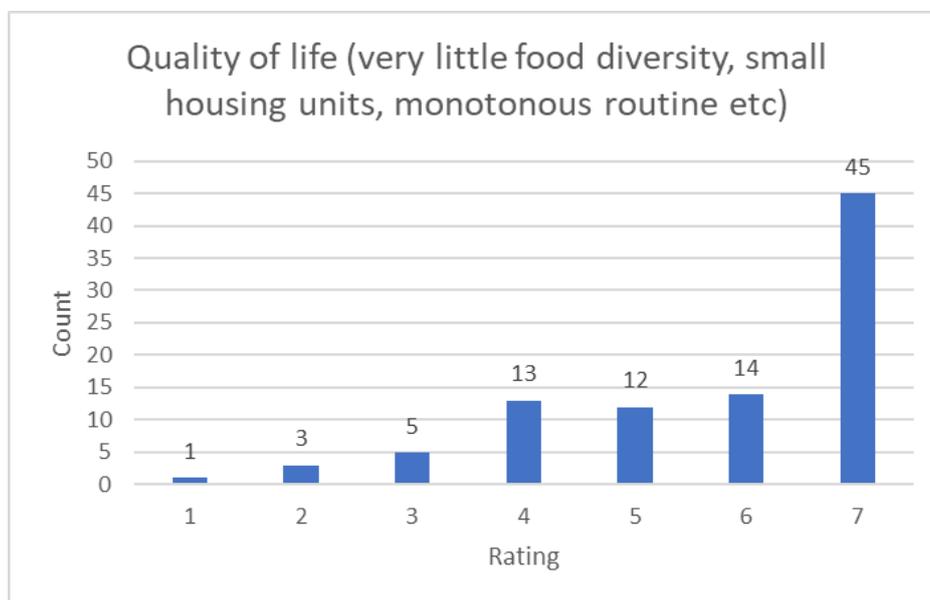


Figure 9: Respondents' ratings on how important Quality of Life is to their willingness to settle on Mars

The respondents rated the importance of Quality of Life on a scale of 1 to 7 with 7 signifying paramount importance. Nearly half of all respondents (45), rated this factor to be a 7, showing that most respondents considered this to be of paramount importance. Meanwhile, a single respondent rated it a 1, indicating that extremely few respondents consider it to be of no importance to their decision (Figure 9).

The respondents included various age groups, with sufficient representation for each, which shows that in general, Indians are extremely concerned with all the discouraging factors selected when it comes to considering inhabiting Mars.

To process obtained data, two paired T-tests were carried out, along with ANOVA tests and for the qualitative analysis a thematic analysis was done.

In the survey, respondents were asked to rate their willingness to settle on Mars on a scale of 1 to 7, 1 being the lowest ($M = 2.88$, $SD = 1.76$). A pre-post survey was carried out and they had seen 2 videos providing context and information regarding the challenges of a Martian settlement and the effects of microgravity and radiation on the human body, they were again asked to do the same ($M = 3.38$, $SD = 1.73$), showing a significant increase $t(91) = 1.66$, $p < 0.05$ (Table 3).

Table 3: Paired T-test of the Willingness to Move to Mars before and after watching two videos with relevant information (N = 93)

Source	Before		After		t	p
	M	SD	M	SD		
Willingness to move to Mars	2.88	1.76	3.38	1.73	18.8	0.000

Note. * $p < .05$

Table 4 depicts that the respondents were asked to rate how much knowledge they felt they possessed regarding the challenges that humanity would face while attempting to create a Martian settlement ($M = 3.15$, $SD = 1.57$), and a pre-post survey was carried out. ($M = 4.52$, $SD = 1.35$), and the difference in means was significant, $t(91) = 1.66$, $p < 0.05$.

Table 4: Paired T-test of the respondents' knowledge of the challenges of creating a Martian settlement before and after watching two videos with relevant information (N = 93)

Source	Before		After		t	p
	M	SD	M	SD		
Knowledge of the Challenges of Creating a Martian Settlement	3.15	1.57	4.52	1.35	32.0	0.000

Note. * $p < .05$

To determine the statistical significance of the mean differences, a one-way ANOVA was run. The one-way ANOVA for encouraging factors shows that the differences between the mean ratings of the level of importance of the four distinct factors of settling on Mars are statistically significant:

Table 5: One-way Analysis of Variance of Importance of these Encouraging Factors in Respondents' Willingness to go to Mars

Sources	SS	df	MS	F	P value
Between Groups	87.77	3	29.26	.06	0.000
Within Groups	1189.01	368	3.23		
Total	1276.78	371	3.44		

Note. * $p < .05$

It can be concluded these differences are statistically significant since the p-value is immensely lower than the Alpha value of 0.05. A main effect of encouraging factors has been seen $F(3, 368) = 9.06, p < .05$. Participants reported the importance of advancing research and innovation in their willingness to go to Mars ($M = 4.27, SD = 0.19$).

To determine the statistical significance of the mean differences, a one-way ANOVA was run. The one-way ANOVA for discouraging factors shows the differences between the mean ratings of the level of importance of the five distinct factors of settling on Mars are statistically significant:

Table 6: One-way Analysis of Variance of Importance of these Discouraging Factors in Respondents' Willingness to go to Mars (N=93)

Sources	SS	df	MS	F	P value
Between Groups	107.28	4	26.815	11.21	0.000
Within Groups	1100.17	460	2.39		
Total	1207.45	464	2.60		

It can be concluded these differences are statistically significant since the p-value is immensely lower than the Alpha value of 0.05. A main effect of encouraging factors has been seen $F(3, 368) = 9.06, p < .05$. Participants reported the importance of impacts on their body due to radiation and microgravity in their willingness to go to Mars ($M = 5.75, SD = 0.16$), closely followed by quality of life ($M = 5.73, SD = 0.16$).

Table 7: Thematic analysis of the responses on respondent's first thoughts about the phrase "Human life on Mars" (N = 93)

Theme	Respondents	Percentage	Few responses
Positive about the possibility of a Martian Settlement	22	23.7%	"Taking over space, adventure, survival necessities" "Possible with evolving tech, but it will take its due course of time"
Express neither a positive nor a negative, or both, opinion	10	10.8%	"Exciting but challenging" "We'll get there eventually but not anytime soon"
Negative about the possibility of a Martian Settlement	30	32.2%	"Advance, risky, limited" "Not likely to happen"
Completely against the concept and possibility of a Martian settlement	14	15.1%	"Impossible" "Horror, destruction, end of life as we know it"

About 24% of respondents gave responses that fit under the theme ‘Positive about the possibility of a Martian settlement’ which means that they were optimistic and excited about the chance of humans living on Mars. This includes both support for Martian settlements, as well as space exploration, regardless of why they do so. Approximately 11% of the respondents showed an inclination towards neither positivity nor negativity about Martian settlements and space exploration, which means that they were either entirely indifferent to the project or simply thought that the pros and cons balanced each other out. 32% of the respondents were negative about the possibility, which indicates that, for several reasons, they would rather not have the mission happen at all, much less participate in it.

While the responses were quite mixed, approximately two thirds of the respondents were negative or extremely negative about the possibility of a Martian settlement. This shows that most of the respondents were not interested in participating in such a mission or having such a mission at all. The plurality of respondents was from the 35-50 years old age bracket, whose image of space exploration is composed of science fiction to a considerable extent, and things that were touted as unrealistic during their childhood is possible now, which may have played a role in a large portion of the respondents being negative and unenthusiastic about this.

Conclusion

The results of this research paper can be used by companies or even governments later in the future, to gauge how to market their missions related to Mars, even if they are not regarding settlement on the Red Planet. This could allow them to garner much greater public support, which could mean more investments for the private companies. There may also be a use for this research in the fields related to the study of the human mind and behaviour, as peoples’ perceptions can offer great insight into the thought processes and psyche of people.

The vast majority of these people would have formed their perceptions based on content and media they consumed from YouTube, or social media platforms as it is not a mainstream topic that is normally seen being discussed unless there is a Mars-related mission occurring. This would support these results, as it is commonly seen that social media and most YouTube videos often champion innovation and progress rather than focusing on the other aspects of these missions.

Limitations

There were several limitations to the methodology, and so the results of this study. Firstly, the ratings of importance of the factors are simply what the respondents themselves believe they are, which may not always be objectively true since it could be subject to various biases. Further, due to the method of data collection being an online survey, it cannot be known whether the respondents watched the provided videos and whether they gave the survey questions some thought.

Secondly, the sample size was only 93 people, nearly all of whom are Indian and are of socioeconomically well-off communities. This size is not enough to generalise the results of this study to any larger group. Moreover, nearly 70% of the sample size was male, and 42% of the respondents were in the age bracket of 36 - 50 years old; this disproportionate representation could also cause skewed results.

Lastly, the study was conducted for a select few factors, thus not providing a holistic image of what affects humans’ willingness to go to Mars the most, since there could be factors that were beyond the scope of this study but are more important.

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