

Gravity Well Entry Motion Sickness CLIFF Peer Review

1. *Strength of evidence presented in CLIFF in modeling the characteristics and mission impact of this medical condition within the spaceflight environment?*

Score: 2

Grading Scale:

4 - *Confident*

3 - *Somewhat confident*

2 – *Neutral*

1 – *Somewhat unconfident*

0 – *Not confident*

2. How confident are you that these data accurately represent the spaceflight environment?	Tables 1, 2 Composite Incidence and Level of Confidence	Table 3, 4 BC/WC Loss of Crew and probability	Table 4 - Clinical Phase 1, 2 durations Table 5 – CP 2 Loss of Crew	Table 4 – RTDC % Table 6 – RTDC Loss of Crew	Table 4 – Loss of Crew Life % Table 7 – Loss of Crew Life, Loss of Crew	Table 8 – TI
Score	2	1	2	3	3	3

Comments and limitations:

1. General comments. This CLIFF characterizes entry motion sickness in a “gravity well” defined as the return to a partial gravitational field after having spent time in microgravity. This could include landing on the lunar or the Martian surface after orbiting or directly approaching these bodies. Entry motion sickness is the collection of physiologic changes that occur when reacclimating from a microgravity environment. Based on prior low earth orbit missions with a terrestrial return, it is usually a self-limited condition, mild in severity for shorter missions, resembling acute terrestrial motion sickness with mostly nausea and vomiting. This, however, is the experience with return to 1 g conditions. None of the 12 Apollo astronauts reported such symptoms upon entering the 1/6 g environment on the lunar surface while there were 228 documented events among 664 shuttle astronauts experiencing re-entry. Based on these differences, the strength of the gravitational field appears to have an important influence on the incidence. The best case is considered to be entry motion sickness that results in nausea/vomiting that responds to behavioral modifications and/or medications. The worst-case definition is entry motion sickness that results in nausea/vomiting and does not respond to behavioral modifications and/or medications. Since the gravity transition will

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be from microgravity to 1/6 g or 3/8 g instead of 1 g, the editor anticipates that all EMS events will be best case scenarios.

2. Incidence. The incidence of gravity well entry motion sickness (specifically defined as readaptation occurring on return to a partial gravitational field from microgravity) has been estimated based on the Apollo moon landings. There is no other analog that can be used to compute incidence. There were 0 documented EMS events among the 12 astronauts who have walked on the moon compared to the 228 documented events among 664 crew returning to earth on shuttle flights (LSAH data). It is unknown what the effect of the 3/8 g Martian gravitational field will be on the incidence of entry motion sickness. The editor assumes that all episodes will be mild and therefore places the best-case probability at 100%. Therefore, all worst-case data was listed as zero. The clinical phase durations are based on astronaut re-entry data. RTDC and Loss of crew life probabilities are estimated to be zero which is a reasonable assumption. The probability density curve that was derived appears to be a reasonable representation of the data presented.

3. Clinical phase data. I am in agreement with the clinical phase 1 duration entered in this CLIFF. This data was compiled by a team of expert clinicians, and I was involved in the discussions leading to the calculation of the clinical phase duration. CP2 was supported by terrestrial evidence.

4. Task impairment. The analysis was performed and reviewed by a separate team of expert clinicians. I am aware of the methods that were used but did not directly participate in the discussions.

5. Dependence on mission phase or duration of mission. This medical condition is dependent on mission phase as it only occurs when there is re-entry from microgravity to a positive gravity field such as landing on the lunar or Martian surface.

6. Limitations

- There is very limited data to support this CLIFF. Only 12 astronauts have experienced a microgravity to lunar gravity transition and none of them reported entry motion sickness symptoms.
- It is possible that Apollo astronauts under-reported entry motion sickness symptoms.
- There is no data to support the incidence of entry motion sickness upon entering the Martian 3/8 gravitational field. It is possible that the incidence will be somewhere between the Apollo moon landing experience and that of shuttle astronauts.
- At some future point, it would be advisable to have separate incidences for Martian and lunar landings, given the difference in gravitational fields.
- The assumption that there will be no worst case is questionable. An appropriate worst case definition might be: "EMS that results in symptoms that do not respond to behavioral modifications and/or medications OR interferes with mission objectives/crew safety." An example of that might be a pilot being unable to make a safe landing on Mars because of EMS symptoms or any crewmember who was unable to perform a mission-critical task. This could be during the landing phase or immediately post-landing.
- As a result of the current BC/WC probabilities, all entries for worst case are zero.
- The incidence calculates the probability of having entry motion sickness for each crewmember onboard. However, the consequences of motion sickness depend on the individual crew responsibilities. For example, there would be more potential mission impact if the pilot or commander of the landing vehicle became ill than if a crewmember without mission-critical responsibilities became ill.

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Reviewed by:

David C. Hilmer