

Burn Mild 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	2	3	3	3	3

Comments and limitations:

1. **General comments.** This CLIFF characterizes mild thermal burns resulting from any source of heat that may be present in the spacecraft, whether a result of a failure in heat-emitting equipment used in normal operations, an experiment, a scald from a liquid, or a fire. Mild burns are considered to be either first degree (superficial) or second degree (partial thickness). There is a separate CLIFF that addresses moderate to severe skin burns. The risk largely depends on the engineering safeguards built into the system to mitigate the risk of exposure as well as crew diligence and operational safety measures. There has been a large fire reported during spaceflight on a Mir mission and smaller ones on the Space Shuttle. One crew member on MIR suffered a burn which was primarily superficial but did have blistering consistent with a partial thickness burn. The best case is considered to be superficial burns to the skin that resolve without treatment. The worst case is an isolated superficial-partial thickness burn to the skin that responds to topical treatments, dressings, and/or NSAIDs/acetaminophen.

Burn Mild CLIFF Peer Review

2. Incidence. It is difficult to calculate incidence since the risk is largely dependent on engineering safeguards which can vary with vehicle design. The best data comes from the ISS probability risk assessment (PRA) fire model which calculates the risk that at least one crew member is in a module when a fire event occurs that requires a crew response. While this is a poor surrogate for the risk of burns, it is the most reasonable substitute to use since the spaceflight experience with burns is very limited. It is likely that a crewmember would be able to extinguish a fire without being burned. It is also possible that burns could be caused by sources other than fire. The ISS data was normalized to person-years and then adjusted by the American Burn Association repository data to divide the incidence between mild and moderate-severe cases. An Artemis-specific PRA is under development but is not yet available. It is felt that the risk in the Artemis program will be lower than that of ISS because of fewer pieces of experiment equipment and the presence of automatic thermal shutoff designs. The best case/worst case probabilities used data from a study looking at the proportion of mild burns presenting to a Swiss emergency center that were superficial and those that were partial thickness. It is very likely that this study is weighted heavily towards the worst case since many patients with mild superficial burns do not present to the emergency center. However, this is the only terrestrial study that categorized burns per the BC/WC definitions. The clinical phase durations, RTDC and Loss of Crew Life probabilities are supported by terrestrial evidence, and I am in agreement with their calculation. For mild burns such as defined in this CLIFF the risk of return to definitive care (RTDC) and Loss of Crew Life were both considered to be zero. Complications of untreated WC burns such as cellulitis are considered in other CLIFFs. 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 not dependent on mission phase.

6. Limitations

- The best data to calculate incidence comes from the ISS probability risk assessment (PRA) fire model which calculates the risk that at least one crew member is in a module when a fire event occurs that requires a crew response. While this is a poor surrogate for the risk of burns, it is the most reasonable substitute to use since the spaceflight experience with burns is very limited. It is likely that a crewmember would be able to extinguish a fire without being burned. It is also possible that burns could be caused by other sources than fire.
- The vast majority of minor superficial burns are treated at home with OTC and home remedies. This cohort is very difficult to capture in burn literature and thus skews the BC/WC probability toward more significant (partial thickness) burns which are evaluated in the hospital.
- There have been several fires in spaceflight such as during the Mir program; however, extensive engineering risk mitigation has been performed to reduce this risk.
- A PRA has not yet been published for Artemis missions. However, it is anticipated that due to the fewer number of experiments on board the risk of fire will be much less than that on

Burn Mild CLIFF Peer Review

ISS. Risk of fire and risk that a crew member is present is a surrogate for skin burn and likely significantly overestimates the true risk of burn

- The BC and WC in this scenario are very similar with regards to burn severity. The vast majority of superficial burns will heal without intervention. Gauze and ointment may help reduce pain and improve healing, but in a minor injury the impact of this treatment is expected to be minor.

Reviewed by:

David C. Hilmers