

## EVA Related Hand Injury 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: 3

### **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<br>Composite Incidence and Level of Confidence | Table 3, 4<br>BC/WC<br>Loss of Crew and probability | Table 4 -<br>Clinical Phase 1, 2 durations<br><br>Table 5 – CP 2 Loss of Crew | Table 4 – RTDC %<br><br>Table 6 – RTDC Loss of Crew | Table 4 – Loss of Crew Life %<br><br>Table 7 – Loss of Crew Life, Loss of Crew | Table 8 – TI |
| Score                                                                                      | 3                                                          | 3                                                   | 2                                                                             | 4                                                   | 4                                                                              | 3            |

### Comments and limitations:

**1. General comments.** This CLIFF addresses hand injuries sustained during EVA's and includes abrasions and repetitive stress injuries resulting in pain, swelling and fatigue. Small hand lacerations and abrasions are among the most common injuries occurring during EVA's and, in fact, during all of spaceflight. Factors that predispose to injury include small hand size, left-handedness, glove model, moisture in the glove, and longer EVA duration. It has been suggested that wound healing in weightlessness is delayed due to altered cellular immune function which may result in a longer convalescence. Glove design has been implicated in EVA hand injuries, and important advances have been made throughout the space program to improve the comfort and safety of the gloves. It is unclear how well historical data that documents the rate of hand injuries in older suits will inform the incidence in newer designs. Since some hand injuries during an EVA are of minor consequence, they may go unreported. The best case is considered to be abrasions sustained secondary to repetitive hand movements within the EVA suit. The worst case is hand/finger pain, fatigue, and/or swelling secondary to repetitive use of the hands and fingers in the EVA suit. The condition definition does not include fingernail delamination, which is covered by a separate condition (ICL41 - EVA Related Fingernail Delamination). It is important to note that unlike other CLIFFs, the "best-case

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scenario and worst-case scenario" in this CLIFF are considered "Category 1 and Category 2" definitions. That is, they are separate entities that do not occur on a best-case, worst-case spectrum like a typical CLIFF.

**2. Incidence.** A review by Scheuring et al. (2009) was used to inform the incidence distribution for this condition. This study reviewed missions from Mercury – ISS Expedition 13. There were 20 hand injuries reported by astronauts during EVAs that fit the definition of this CLIFF. The incidence calculation was derived on a person-EVA basis. Since the exploration space suits and gloves will presumably incorporate improvements in design, it is possible that the incidence of hand injuries will be lower than historical experience. It is likely that very minor hand injuries have not been reported in the past which could lead to a small underestimate of the true incidence value. The best case/worst case probabilities used data from a prospective observational study and a retrospective study, both investigating the frequency of hand injuries sustained by astronauts during EVA training runs. Of reported events fulfilling the definition of this CLIFF, 81.7-87% met the best case definition. It is important to note that unlike other CLIFFs, the "best-case scenario and worst-case scenario" in this CLIFF are considered "Category 1 and Category 2" definitions. That is, they are separate entities that do not occur on a best-case, worst-case spectrum like a typical CLIFF. Therefore, CP2 times are longer for best case (category 1) than for worst case (category 2). Clinical phase duration, RTDC and Loss of crew life probabilities are supported by terrestrial or spaceflight evidence, and I am in agreement with their calculation. Both RTDC and Loss of crew life probabilities were considered to be zero given the medical condition definition. 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 is only applicable to EVA operations.

### 6. Limitations

- Under-reporting for this condition could have occurred during past space missions due to subtle hand injuries that were not of clinical consequence. This may result in underestimation of the incidence.
- The incidence was based on historical data from past spaceflights which used EVA suits that will not be utilized in future missions. Since the exploration space suits and gloves will presumably incorporate improvements in design, it is possible that the incidence of hand injuries will be lower than historical experience.
- No literature identifying the length of symptoms of hand pain, fatigue, and swelling post-EVA could be found. Therefore, the durations for the worst-case scenarios were based on cursory data from LSAH post-EVA PMCs from recent EVAs on ISS.
- RTDC and Loss of crew life were assumed by the ExMC editor of this CLIFF to be 0% and no literature searches specific to RTDC or Loss of crew life were performed.
- Unlike other CLIFFs, the best and worst-case scenarios for this CLIFF are defined as "Category 1" and "Category 2" indicating that they are separate entities that do not occur on a best-

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case/worst case spectrum as most other conditions do. Thus, the "worst-case scenario" (Category 2) CP2 durations are shorter than the "best-case scenario" (Category 1) CP2 durations in this CLIFF. In spaceflight, it is not uncommon for crewmembers to have symptoms from both categories (abrasions and swelling/fatigue) concurrently. The MEDPRAT model, however, will pick one category or the other based on the best and worst-case probabilities provided by this CLIFF.

Reviewed by:

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