

## Arm Fracture 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<br>Composite Incidence and Level of Confidence | Table 3, 4<br>BC/WC<br>Loss of Crew and probability | Table 4 - 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                                                                                      | 2                                                          | 2                                                   | 3                                                                          | 2                                                   | 3                                                                              | 3            |

### Comments and limitations:

1. **General comments.** For this CLIFF, arm fractures refer to any fracture of the humerus, elbow, or radius/ulna excluding the distal portion of the radius/ulna. Distal radius/ulnar fractures are covered by ICL56 - Wrist Fracture. Hand Fracture is also the subject of its own CLIFF. There has never been an arm fracture reported during spaceflight and the risk of fracture during microgravity operations is considered low enough to disregard. For purposes of this CLIFF, only EVA surface operations are considered to have a risk of arm fractures. The best case arm fracture is considered to be a closed, non-comminuted, non-segmented, non-displaced, or minimally displaced fracture resulting in no neurovascular compromise to the affected limb. The worst case is a fracture that is: open, comminuted, segmented, moderately to severely displaced, intra-articular, or results in neurovascular compromise to the affected limb, likely requiring surgical intervention.

2. **Incidence.** As has been done on other fracture CLIFFs, the risk of traumatic arm fractures in microgravity is considered to be close enough to zero to disregard. A terrestrial retrospective epidemiologic study in the USA which examined arm (proximal and distal humerus and forearm) fractures was used to determine the incidence. It excludes distal radius/ulnar fractures which are

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covered in another CLIFF. It is likely that this value results in an over-estimate of the true incidence since the lunar and Martian gravitational fields are weaker than the Earth's. The best case/worst case probabilities used data from a classification system of fracture types. The range of fractures that met the worst case definition was 9.4%-39%. The clinical phase durations, RTDC and Loss of crew life probabilities are supported by terrestrial evidence, and I am in agreement with their calculation. Loss of crew life probability for the worst case untreated condition was determined to be 0-50% based on SME opinion since there is no data to support this estimate. All other Loss of crew life probabilities were considered to be zero. 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 calculated during surface EVA operations.

### 6. Limitations

- Since terrestrial data is used to calculate the incidence, it is likely that there is an over-estimation of the true incidence since the Lunar and Martian gravitational fields are weaker than the Earth's.
- Incidence is informed by Karl et al, 2015 which includes fractures from all ages of patients and could therefore be an overestimate.
- Studies informing the duration, RTDC, and Loss of crew life for all scenarios are limited to humeral fractures. No data for radial or ulnar fractures were included.
- There is a paucity of data available to inform Loss of crew life probability for the untreated worst-case scenario. Ultimately, the Loss of crew life probability range was assigned based on subject matter expertise of the CLIFF editor.

Reviewed by:

David C. Hilmer