Clinical Finding Form (CliFF)

Branch	Baseline

ICL104_Sprain/Strain - Upper Extremity

Sprain/Strain – Upper Extremity is a broad condition including strains (muscle/tendon) or sprains (ligaments) anywhere in the upper extremity.

INCIDENCE DATA INCLUDED IN THE MODEL

The model imports the following incidence information from the MEDPRAT Evidence Library Database: incidence data category, space adaption status, EVA status, incidence data type, incidence and occurrence distribution data and incidence data characteristics. Data category defines the type of data available for incidence calculations (i.e. raw data vs. adjusted data). Space adaptation identifies medical events that where onset occurs in the first 5-7 days of flight and does not reoccur. EVA-related incidence values identify medical events that occur only during an EVA. Incidence values types vary by data category and define the number of medical events per person-year (rates) or medical events per person at-risk (proportion) for each medical condition. Incidence values can be modified by crew characteristics such as gender sex and certain crew medical history characteristics. Modifying characteristics are noted below and incidence values are listed individually for each characteristic. Distributions are assigned to medical events incidence values and occurrences in the model. For each crewmember in a given trial, the incidence and number of occurrences of each medical condition are randomly selected from these probability distributions. Detailed descriptions of the distributions are included in the MEDPRAT Technical Description Document.

INCIDENCE DATA

SPACEFLIGHT LITERATURE

Johnston III, et al. (2020) provides discrete numbers of in-flight wrist, elbow, and shoulder sprain/strain injuries in US astronauts for missions Mercury - ISS Expedition 13. The individual IMM CLiFFs for each of these corresponding conditions then provided updated values through Expedition 40. There have been a total of 67 sprain/strains (23 Elbow, 35 Shoulder, and 9 Wrist) from Mercury - ISS Expedition 40. This will be used to inform the incidence distribution of this CLiFF (NASA, Elbow Sprain/Strain CLiFF, 2017; NASA, Wrist Sprain/Strain CLiFF, 2017;NASA, Shoulder Sprain/Strain CLiFF, 2017). Scheuring, et al. (2009) is a retrospective review of musculoskeletal injuries in US Spaceflight from Mercury - ISS Expedition 13. The following data sources were utilized in this review: post-flight medical debriefs, the LSAH medical record database, the Johnson Space Center (JSC) electronic medical record system, including ASCR specialist assessment and treatment logs, and the JSC Flight Medicine Clinic vault records. Musculoskeletal injury data in the ISS program was extracted from the private medical conferences held between the ISS crewmembers and their flight surgeon up to and including Expedition 13, as well as from the ASCR specialists supervising the crewmember's in-flight training regimen. Lastly, several entries came directly from personal communications with astronaut crewmembers or flight surgeons and the authors when not otherwise duplicated. Information collected on each injury included location, type, and a detailed narrative on the mechanism of injury, the type of exercise the crewmember performed during the flight, previous history of injury, treatment, and post-flight outcome. The term " in-flight" included lunar surface operations. It reports 54 sprain/strain injuries in this timeframe, but does not specify how many occurred in the upper extremities. This was not used to inform the incidence for this condition. Viegas, et al. (2004) is a review that provides upper extremity injury data for NBL training runs. A total of 83 astronauts completing 548 training sessions experienced 202 had suit fit problems of the upper extremity. This is not applicable to upper extremity sprain/strain injuries in spaceflight and was not used to inform the incidence.

ANALOG LITERATURE

Analog studies from the military, occupational workers, and race car drivers were identified in the literature. They are not as representative of the astronaut corps population as the spaceflight data and were thus not used to inform incidence for this CLiFF. Stahlman, et al. (2018) is an analog study that describes the incidence, trends, types, causes, and dispositions of acute injuries among active duty members by anatomic region. From 2008 through 2017, there were more than 3.6 million acute injuries among more than 1.6 million individuals. The highest rates were for injuries to the foot/ankle, head/neck, and hand/wrist. Overall, service members in the Army and service members in motor transport and/or combat-related occupations tended to have higher incidence rates than their respective counterparts. "Sprains and strains" were the most common type of injury (48.5%) with an incidence of 0.033 upper extremity sprain/strains per person-year. Gerr et al, 2014 characterized associations between physical risk factors and upper-extremity musculoskeletal symptoms/disorders among 386 manufacturing workers. An individual, task-based exposure assessment strategy was used to assess upper-extremity exertion intensity, repetition, and time-in-posture categories. Overall, incident symptoms and disorders were common. The incidence of hand and arm symptoms was 58 per 100,000 person-year, hand and arm "disorders" 19 per 100,000 person-years. The incidence of neck and shoulder symptoms was 54 per 100,000 person-years and neck and shoulder "disorders" was 14 per 100,000 person-years. Bovenzi, et al (2014) was a three-year prospective follow-up study examining the occurrence of neck and shoulder pain (NSP) frequency, duration and intensity within a population of 537 male professional drivers. Overall, authors observed that cumulative whole-body vibration exposure, physical load factors and adverse psychosocial environments (as well as individual-related psychological distress), were significant predictors of the occurrence of NSP in the professional drivers. 21.4% of professional race car drivers in the study, over 12 month period, experienced neck and shoulder pain.

TERRESTRIAL LITERATURE

No relevant terrestrial literature was found to inform this CLiFF.

OVERALL INCIDENCE SUMMARY

INCIDENCE

Mean: 1.502 SD: 0.1852

INCIDENCE SUMMARY

The incidence for this condition is informed by Johnston III et al, 2020; NASA, Wrist Sprain/Strain CLiFF, 2017; Elbow Sprain/Strain CLiFF, 2017; Shoulder Sprain/Strain CLiFF, 2017. In the US Space Program from Mercury – ISS Expedition 40, there have been a total of 9 wrist strain/sprains, 23 elbow sprain/strains, and 35 shoulder sprain/strain events over 44.58 person-years. Total events 67 over 44.58 person-years of flight. IR: 1.503 (95%CI: 1.174, 1.897). This Bayesian posterior distribution given the inflight data (67 events over 44.58 person-years) under an uninformative prior is Gamma(shape=65.77, rate=43.79) with mean 1.502 and SD 0.1852.

TABLE 1. INCIDENCE MODEL

Incidence Details

Incidence Type
General

Segment
All

Env. Exposure
NA

Sex
Any

Crowns
Any

Contacts
Any

Pregnancy
Any

Incidence Distribution

Occurrence Dist
Poisson

Incidence Dist.
Gamma

Mean
1.50194

SD
0.185199

Gamma
(Shape): 65.77
(Rate): 43.79

TABLE 2. INCIDENCE LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Viegas et al, 2004	Spaceflight	1
Stahlman, 2018	Analog	0
Bovenzi, 2015	Analog	0
Scheuring et al, 2009	Spaceflight	2
Gerr et al, 2014	Analog	0
Johnston III et al, 2020	Spaceflight	4
NASA, Elbow Sprain/Strain CLiFF, 2017	Spaceflight	4
NASA, Shoulder Sprain/Strain CLiFF, 2017	Spaceflight	4
NASA, Wrist Sprain/Strain CLiFF, 2017	Spaceflight	4

Viegas et al, 2004 is a review of overuse injuries of the hand an upper extremity and presents suit contact injuries during NBL runs. While this is in the astronaut population, it is not spaceflight data and represents a gross overestimation of upper extremity sprains/strains because hand injuries (particularly secondary to the EVA suit) are the most common musculoskeletal injury inflight. Scheuring et al, 2009 presents in-flight data regarding sprains/strains in general (not specified to anatomic location) and upper extremity injuries. For the reasons stated for Viegas et al, 2004, upper-extremity injuries will be a gross overestimation of sprains/strains. Johnston III et al, 2020 presents discrete number of events for shoulder, elbow, and wrist in-flight sprains/strains from Mercury - ISS expedition 13. The IMM CLiFFs for Elbow, Shoulder, and Wrist sprain strain provide Real World updates from 2017 that update the values of shoulder, elbow, and wrist sprain/strain through ISS Expedition 40. Therefore Johnston III et al, 2020 and the prior CLiFF updates will be used to inform this incidence. Analog studies (Stahlman, 2018; Bovenzi, 2015; Gerr et al, 2014) are anticipated to be an overestimation of the incidence due to occupational demands.

CREWMEMBER SELECTION/PREVENTION

DISQUALIFYING CONDITIONS

Refer to Medical Evaluation Documents (MED) Volume A, Medical Standards for ISS Crewmembers, International Space Station Program, Rev 3.4 (2016).

PREFLIGHT PREVENTATIVE MEASURES

The Astronaut Strength, Conditioning and Rehabilitation (ASCR) program and Astronaut gym at Johnson Space Center are strategic to providing pre-flight strengthening in attempts to prevent or mitigate injuries as well as post-flight rehabilitation. The Strength Coach's primary role is to provide an exercise plan designed to achieve flight physical readiness and prevent musculoskeletal injuries during spaceflight training.

BEST CASE SCENARIO DEFINITION

A Grade I or II strain/sprain in which there is minimal or partial muscle or ligamentous tearing.

WORSE CASE SCENARIO DEFINITION

A Grade III strain/sprain in which there is full thickness muscle or ligamentous tearing, and/or instability.

CONDITIONS INCLUDED, BUT NOT EXPLICITLY STATED (CNES)

Sprain/Strain - Shoulder Sprain/Strain - Elbow Sprain/Strain - Wrist Sprain - Finger Finger tendon injury

BEST CASE/WORST CASE PROBABILITY COMMENTS

There is a paucity of data to inform the best and worst-case probabilities according to this CLiFFs definition. Literature regarding need for surgical intervention is the best surrogate available to inform these probabilities. Rettig et al, 2001 and Park et al, 2010 are reviews that attempted non-operative treatment for elbow medial collateral ligament and the triangulofibrocartilage complex (TFCC), respectively. They each report a failure of non-operative treatment rate of 42%. This is likely to be an overestimate of the worst-case scenario for all-comer upper extremity sprains/strains because it is based on two areas known to require surgical intervention in some cases. It is also based on patients who presented for care. Especially in the case of medial collateral ligament tears, this is typically restricted to elite athlete throwing arms (pitchers) and the age range is much lower than the astronaut population. To account for this suspected overestimation, a range was assigned. Best-case scenario probability was assigned 58-100%, worst-case scenario probability was assigned 0-42%.

TABLE 3.BEST/WORST CASE PROBABILITY LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Rettig et al, 2001	Terrestrial	2
Park et al, 2010	Terrestrial	2

Rettig et al, 2001 is a retrospective study of 31 overhead throwing athletes with symptoms and physical examination findings indicating ulnar collateral ligament tear (worst-case scenario) or insufficiency (best-case scenario) from 1994 to 1997. The average age of participants was 18 years old. All athletes were attempted conservative treatment with physical therapy. "Thirteen of 31 athletes (42%) were able to return to their sport at the level played before injury at an average of 24.5 weeks after diagnosis (range, 13 to 54 weeks). Those athletes whose nonoperative treatment was unsuccessful had symptoms for an average of 16.8 weeks (range, 1 to 52) at the time of their initial evaluation." Park et al, 2010 is a retrospective review of patients with triangulofibrocartilage complex (TFCC) wrist injuries. patients were selected using ICD-9 codes matching wrist pain and/or wrist ligamentous injuries on their initial consultation, who also had a positive TFCC grind test. All patients were attempted to be treated non-operatively for a minimum of 4 weeks in a short arm cast or volar wrist splint. 42% ultimately required surgical intervention.

TABLE 4. CLIFF TREATMENT & OUTCOME TABLE BY CLINICAL PHASE

Case Scenario	Composite Incidence	Condition Probability %	CP1: Diagnosis		CP2: Treatment			CP3: Condition End State				
			TI%	Duration	TI%	Duration		TI%	RTDC		LOCL	
			Preset	Preset	Preset	Min	Max	Preset	Min%	Max%	Min%	Max%
Treated Best Case (TBC)	Mean: 1.502 SD: 0.1852	97 - 100	100	1	10.5102	240	504	0	0	0	0	0
Treated Worst Case (TWC)		0 - 3	100	1.6	19.2665	1008	4320	17.5126	0	0	0	0
Untreated Best Case (UTBC)	N/A	N/A	N/A	1	19.333	1008	1344	0	0	0	0	0
Untreated Worst Case (UTWC)	N/A	N/A	N/A	1.6	29.2719	8760	66576	17.5126	0	0	0	0

TABLE 4 KEY

Composite Incidence: The same composite incidence will be used for both TBC and TWC. For EVA conditions: events per EVA (events/EVA). For space adaptation conditions: events per person (events/person). For non-spaceflight conditions: events per person year (events/py).

Condition Probability: The probability that CLiFF condition progresses to a worst case scenario. Best case scenario: 100%-Worst Case.

Clinical Phase General Comments:

- TI% = Task Impairment %. Task Impairment is the % of tasks that the crewmember is incapable of performing without impairment secondary to the medical condition.
- Durations are defined in hours.
- Removal to Definitive Care (RTDC): The probability the entire crew aborts the mission and returns to earth. This is considered as a condition end state result if any of the following criteria are met: 1) the potential for LOCL, 2) potential for significant permanent task impairment, or 3) potential for intractable pain.
- Loss of Crew Life (LOCL): The probability of death of affected crewmember due to medical condition.

Clinical Phase 1: Initial Assessment and Diagnosis:

- Covers only the initial assessment and diagnosis of the affected crewmember to define his or her medical condition. While the affected crewmember is being assessed, he or she is not able to perform any assigned tasks, thus Task Impairment (TI) during this phase is considered 100%. In the untreated case, there is no diagnosis performed, therefore Task Impairment and Duration will always be " not applicable."

Clinical Phase 2: Stabilization, Treatment, and Convalescence:

- The affected crewmember is receiving any appropriate initial or follow-on treatment for his or her medical condition to allow the crewmember to recover as much as he or she is able to recover in the spaceflight environment. Clinical phase 2 also encompasses relapses or recurrences of the same original medical condition in Clinical Phase 1. The duration of Clinical Phase 2 is expressed as minimum and maximum hours.

Clinical Phase 3: Condition End State:

- Reached once the affected crewmember has recovered from the medical condition as much as he or she is able to recover in the spaceflight environment amongst treated and untreated best and worst case scenarios. This may or may not be recovery from the given medical condition to the full extent possible. If this “recovered” state results in Removal to Definitive Care (RTDC) or Loss of Crew Life (LOCL) this will be noted in the condition end state results.

SCENARIO OVERVIEW COMMENTS

The RTDC surrogate selected for this condition was hospitalization and/or surgical intervention. There is a paucity of data related to "upper extremity sprains/strains" as defined in this CLiFF. The literature focuses on individual tendons or ligaments, which have varying recovery times, and probabilities for hospitalization or surgery. LOCL probabilities were assigned as 0% for all scenarios due to lack of evidence in the literature of mortality. For many of the scenarios, data is based on rotator cuff tears (sometimes atraumatic, which are a poor surrogate for upper extremity sprain/strain which would be anticipated to be traumatic) and ulnar collateral ligament of the thumb tears.

TREATED BEST CASE (TBC) SCENARIO COMMENTS

There is a paucity of data related to the duration of "upper extremity sprains/strains" as defined in this CLiFF. The literature focuses on individual tendons or ligaments, which have varying recovery times. The minimum duration was assigned 10 days (240 hours) based on the minimum duration of time for healing for an ulnar collateral ligament of the thumb injury (Ritting et al, 2010). The maximum duration was assigned as 3 weeks (504 hours) based on the recovery time for most upper extremity sprain/strains according to the Hand to Shoulder Center of Wisconsin (2021). The Clinical and Science Team of ExMC pre-determined that the RTDC probability for best-case scenarios of this condition was 0%. Thus a probability of 0% was assigned. No literature was identified related to mortality from upper extremity sprains/strains. Therefore the LOCL probability was assigned 0%.

TREATED WORST CASE SCENARIO (TWC) COMMENTS

Upper extremity sprains/strains include any sprain strain in the upper extremity. The length of treatment/healing for different anatomical locations varies widely. Literature does not combine different anatomic locations the way the definition for this CLiFF does. Therefore, individual injuries were used to inform this duration. The minimum duration was assigned 6 weeks (1008 hours) based on immobilization length for ulnar collateral ligament tears of the thumb (Ritting et al, 2010). The maximum duration was assigned 6 months based on recovery times following full thickness rotator cuff tear and distal biceps tear repairs (Srinivasan et al, 2020; Osborne et al, 2016). The RTDC surrogate for this Cliff was initially assigned as need for hospitalization or surgical intervention. Typically, patients present to the hospital due to pain. Pain control could be provided during spaceflight, so this is not a realistic surrogate for RTDC. While a Grade III sprain/strain requiring surgical intervention is possible in spaceflight, it is unlikely that RTDC would be executed for surgical intervention. Rather, pain control and PT would be the mainstay of treatment inflight and surgical intervention would be pursued post-flight. Lack of prompt surgical intervention will be reflected in TI. Thus, the RTDC probability was according assigned as 0%. A literature search of Dynamed, PubMed, and Google Scholar did not result in any articles indicating mortality for this scenario. Thus, LOCL probability was assigned 0%.

UNTREATED BEST CASE (UTBC) SCENARIO COMMENTS

There is a paucity of data related to the duration of "upper extremity sprains/strains" as defined in this CLiFF. The literature focuses on individual tendons or ligaments, which have varying recovery times. The minimum duration was assigned 6 weeks (1008 hours) based on healing time for upper extremity sprains/strains (Hand to Shoulder Center of Wisconsin, 2021) and wrist sprain/strain (American Society for Surgery of the Hand, 2018). The maximum duration was assigned as 3 weeks (504 hours) based on the recovery time for most upper extremity sprain/strains according to the Hand to Shoulder Center of Wisconsin (2021). The maximum duration was assigned 8 weeks (1344 hours) based on healing time for upper extremity sprains/strains (Hand to Shoulder Center of Wisconsin, 2021). The Clinical and Science Team of ExMC pre-determined that the RTDC probability for best-case scenarios of this condition was 0%. Thus a probability of 0% was assigned. A literature search of Dynamed, PubMed, and Google Scholar did not result in any articles indicating mortality for this scenario. Thus, LOCL probability was assigned 0%.

UNTREATED WORST CASE (UTWC) SCENARIO COMMENTS

Itoi and Tabata, 1992 performed a retrospective review of 62 rotator cuff tears in 54 patients between 1980-1989 that were treated conservatively (NSAIDs, injections, etc.), without surgery. They note that those who were followed for 1-3 years had improved scores for pain, motion, and strength, whereas those followed for 6-9 years had significantly lower scores. Therefore, the minimum duration was assigned 1 year (8760 hours). Bokor et al, 1993 is a retrospective study of non-operative treatment for full thickness rotator cuff tears in 53 patients. It should be noted that the average age of participants was 62.2 years old (range 45-83 years old). The average age at presentation for male participants was 60.5 years whereas the average age of female participants at presentation was 67.2 years. It should be noted that approximately half of these patients indicated trauma preceding their shoulder pain (full thickness tear was confirmed with arthroscopy). Thus, the remaining 50% constitute atraumatic, degenerative rotator cuff tears, which is a poor surrogate for worst-case upper extremity sprain/strain in the astronaut in the spaceflight environment. Patients were followed up at 7.6 years post initial visit. Although range of motion and pain had improved in most patients, muscle wasting, and decreased strength persisted. Therefore, the maximum duration was assigned 7.6 years (66,576) based on an untreated full-thickness rotator cuff tear The RTDC surrogate for this Cliff was initially assigned as need for hospitalization or surgical intervention. Typically, patients present to the hospital due to pain. Pain control could be provided during spaceflight, so this is not a realistic surrogate for RTDC. While a Grade III sprain/strain requiring surgical intervention is possible in spaceflight, it is unlikely that RTDC would be executed for surgical intervention. Rather, pain control and PT would be the mainstay of treatment inflight and surgical intervention would be pursued post-flight. Lack of prompt surgical intervention will be reflected in TI. Thus, the RTDC probability was accordingly assigned as 0%. A literature search Google Scholar did not result in any articles indicating mortality for this scenario. Thus, LOCL probability was assigned 0%.

TABLE 5. CLINICAL PHASE II DURATION LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Bokor et al, 1993	Terrestrial	2
Itoi and Tabata, 1992	Terrestrial	
Osborne et al, 2016	Terrestrial	
Ritting et al, 2010	Terrestrial	
Srinivasan et al, 2020	Terrestrial	
American Society for Surgery of the Hand, 2018	Terrestrial	
Hand To Shoulder Clinic of Wisconsin, 2021	Terrestrial	

There is a paucity of data regarding duration of treatment and healing for upper extremity sprains/strains as defined by this CLiFF. The literature does not combine anatomic locations, rather it focuses on individual tendons or ligaments. In particular, the best-case scenario durations were informed by non-peer reviewed websites (American Society for Surgery of the Hand, 2018; Hand To Shoulder Clinic of Wisconsin, 2021). These were the only sources available with reasonable estimates for best-case scenarios as most of the literature focuses on worst-case scenarios. The worst-case scenario durations are heavily informed by studies regarding full thickness rotator cuff tears, and often atraumatic rotator cuff tears (a degenerative process seen with aging, thus a poor surrogate for traumatic upper extremity sprain/strain in spaceflight).

TABLE 6. RTDC LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Kuhn et al, 2013	Terrestrial	1
Landsman et al, 1995	Terrestrial	

RTDC probabilities were informed by atraumatic full-thickness rotator cuff tears (Kuhn et al, 2013) and ulnar collateral ligament tears of the thumb (Landsman et al, 1995). Atraumatic full thickness rotator cuff tears result from a degenerative process, typically in the elderly. The average age of participants in this study was 62.6 years (range 31–90). 25% of participants in this study elected not to undergo surgical intervention after a period of physical therapy, but it should noted that often clinically elderly patients with degerative rotator cuff tears are not recommended for surgery. Atraumatic rotator cuff tears are a poor surrogate for worst-case scenario (full thickness tear) upper extremity sprain/strains, which would be anticipated to be traumatic in nature. Landsman et al, 1995 is specific to ulnar collateral ligament tears of the thumb, which may not be representative of all-comer upper extremity worst-case scenario sprain/strains.

TABLE 7. LOCL LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Kuhn et al, 2013	Terrestrial	3

LOCL probabilities were informed by atraumatic full-thickness rotator cuff tears (Kuhn et al, 2013). Atraumatic full thickness rotator cuff tears result from a degenerative process, typically in the elderly. The average age of participants in this study was 62.6 years (range 31–90). Atraumatic rotator cuff tears are a poor surrogate for worst-case scenario (full thickness tear) upper extremity sprain/strains, which would be anticipated to be traumatic in nature. However, no other articles indicating moratlity from upper extremity sprains/strains were identified. (It is unclear whether the student effort for the literature search for LOCL probability for the untreated worst-case scenario included a PubMed search. It may have been limited to only Google Scholar).

CAPABILITY RESOURCE TABLE (CRT) OVERVIEW

Capabilities and Resourcing Scope Overview WC Definition: A Grade III strain/sprain in which there is full thickness muscle or ligamentous tearing, and/or instability. BC Definition: A Grade I or II strain/sprain in which there is minimal or partial muscle or ligamentous tearing. Sprain/Strain refers to tearing of the muscle or ligament in the region for the condition (i.e. the leg), with the best-case scenario representing uncomplicated tearing or instability and the worst-case scenario representing full thickness tearing and instability. Any strain or sprain, if left untreated, could result in further complications or continued pain and poor functioning of the affected muscle. Both Sprains and Strains are classified according to three degrees of injury. Sprains break down as follows: a first-degree sprain is one in which the ligament fibers are over-stretched but intact, second-degree sprain is one in which some fibers are actually torn, and third-degree sprain is one in which the ligament is completely torn and non-functioning. First-degree strains indicate over-stretching, second-degree indicating partial tear, and third-degree indicating complete tear (rupture) (Reed, 1994). In-flight sprains have generally been mild and self-limited. Diagnostic Scope and Resourcing In the best-case scenario, diagnosis is based on history, and physical examination (musculoskeletal and neurologic). Musculoskeletal ultrasound was considered but it was decided that it would not be necessary to determine if a partial thickness tear was present. It may be a useful adjunct in diagnosis for some cases, but it was not considered a necessary capability to diagnose a partial thickness tear. In the worst-case scenario, diagnosis is based on history, and physical examination (musculoskeletal, neurologic). The utility of musculoskeletal ultrasound would be determined on a case-by-case basis but was considered not needed for this condition. It is used in the LE condition (ICL 102) but not for this one and was included as a non-necessary capability. This diagnostic framework is consistent with the terrestrial workup for sprains/strains with the exception of the inability to perform plain film X-Ray (and if warranted CT or MRI), and thereby using Musculoskeletal Ultrasound as a possible surrogate. Clinical Phase 1 Duration and Rationale This version of IMPACT presumes physician level knowledge, skill, and ability will be present on the mission. The CRT working group SME consensus duration is as follows: CP1 BC (Treated or Untreated): 1.0 hours This is the longest reasonable time to complete this task for an experienced clinician adjusted for being in the spaceflight environment to do the following: 1 - Take a proper history of the patient 2 - Perform a focused neurological and musculoskeletal physical exam on the patient CP1 WC (Treated or Untreated): 1.6 hours This is the longest reasonable time to complete this task for an experienced clinician adjusted for being in the spaceflight environment to do the following: 1 - Take a proper history of the patient 2 - Perform a complete neurological and musculoskeletal physical exam on the patient The highest scope of practice code used in this CRT which includes interpretation of diagnosis, performing diagnostic tests and performing treatment would be a three: this is at a nurse level. Treatment Scope and Resourcing Most best-case sprains/strains in terrestrial populations resolve with reduction in weight loading and symptomatic relief. An initial period of wrapping may be beneficial. Physical therapy is recommended post-immobilization. Pain is variable depending on the patient. NSAIDs and Acetaminophen were included in the best-case and worst-case treatment scenario. Wrapping, using a sling and Splinting were resourced for a worst-case and Physical therapy is recommended post-immobilization. Pain is variable depending on the patient. NSAIDs and Acetaminophen were included in the best-case and worst-case treatment scenario. Communications and Support Needs In the best-case scenario, diagnosis and course of treatment is uncomplicated and likely within the scope of care of onboard crew members. In the worst-case condition, ground communications may be helpful for the ultrasound portion of CP1 but not needed for the rest of the condition. REFERENCES - Reed P. The Medical Disability Advisor. 2nd ed. Horsham, PA: 1994. - Kerstman EL. Conversation with Dr. Kerstman. Saile L, editor. 2011.

IMM CLIFF RECONCILATION COMMENTS

Upper Extremity Sprain/Strain is a unique condition to IMPACT 1.0. IMM included conditions for Shoulder, Elbow, and Wrist Sprain/Strain respectively. Therefore incidence, best and worst-case scenario definitions, durations, RTDC probability, and LOCL probability are unique to this CLiFF.

LIMITATIONS SUMMARY

• The incidence for this condition is based on LSAH/IMM data regarding wrist, elbow, and shoulder injuries. This may be an underestimate of upper extremity sprains/strains overall given the limitation to these three anatomic locations but was felt to be the best approximation for spaceflight incidence of upper extremity sprains/strains available. • There is a paucity of data related to the duration of "upper extremity sprains/strains" as defined in this CLiFF. The literature focuses on individual tendons or ligaments, which have varying recovery times. For many of the scenarios, data is based on rotator cuff tears (which the editor likely would not have included/used as surrogate for upper extremity sprain/strain). • It is unclear whether the student effort for the literature search for LOCL probability for the untreated worst-case scenario included a PubMed search. It may have been limited to only Google Scholar. • There is a paucity of data related to “Upper Extremity Sprains/Strains” the way they are defined in this CLiFF. The literature focuses on individual tendons/ligaments, which makes it difficult to source data for duration, RTDC, or LOCL for all-comer upper extremity sprains/strains. Accordingly, the level of confidence scores assigned by the editor are 2 (Duration), 1 (RTDC), and 3 (LOCL). • There is a paucity of data related to the best-case scenario durations for “Upper Extremity Sprains/Strains” as defined in this CLiFF. Two sources were used to inform these durations that are not peer reviewed: The Hand to Shoulder Center of Wisconsin, 2021 (a private clinic’s website) and the American Society for Surgery of the Hand, 2018 website. Unfortunately, no other sources were found to inform realistic durations for best-case scenario durations. (Most of the literature focuses on worst-case scenario/surgical interventions for tears). • Much of this CLiFF is informed by rotator cuff tears, and in some cases atraumatic rotator cuff tears, which are a degenerative process seen with advancing age. This is not an accurate surrogate for the traumatic injury that would be anticipated to cause an upper extremity sprain/strain in spaceflight.

TABLE 8. TASK IMPAIRMENT CALCULATION BASED ON AFFECTED HUMAN SYSTEMS TASK CATEGORIES (HSTC)

Clinical Phase 2: Treatment												
	Affected HSTCs											
	Cognitive - Simple	Cognitive - Complex	Communications	Inter-personal Skills	Vision	Hearing	Cardio-pulmonary	Dentition	GI	GU		
Treated Best Case (TBC)												
Untreated Best Case (UTBC)		664										
Treated Worst Case (TWC)												
Untreated Worst Case (UTWC)		664		89								
	Affected HSTCs (Continued)								TI Calculation			TI Score
	Hand (Dom)	Hand (Any)	Upper Extremity	Lower Extremity	Ambul & Standing (g)	Translation & Stabilization (microgravity)	Don/Doff Equipment	Pressure Ops	Total Tasks Impaired By Condition	Total Human System Category Tasks Full Mission	TI Decimal	TI %
Treated Best Case (TBC)	132		414				34	211	791	3763	0.210205	21.0205
Untreated Best Case (UTBC)	132		414				34	211	1455	3763	0.38666	38.666
Treated Worst Case (TWC)	132		414				34	211	791	3763	0.210205	21.0205
Untreated Worst Case (UTWC)	132		414				34	211	1544	3763	0.410311	41.0311

Clinical Phase 3: Condition End State												
	Affected HSTCs											
	Cognitive - Simple	Cognitive - Complex	Communications	Inter-personal Skills	Vision	Hearing	Cardio-pulmonary	Dentition	GI	GU		
Treated Best Case (TBC)												
Untreated Best Case (UTBC)												
Treated Worst Case (TWC)												
Untreated Worst Case (UTWC)												
	Affected HSTCs (Continued)								TI Calculation			TI Score

	Hand (Dom)	Hand (Any)	Upper Extremity	Lower Extremity	Ambul & Standing (g)	Translation & Stabilization (microgravity)	Don/Doff Equipment	Pressure Ops	Total Tasks Impaired By Condition	Total Human System Category Tasks Full Mission	TI Decimal	TI %
Treated Best Case (TBC)									0	3763	0	0
Untreated Best Case (UTBC)									0	3763	0	0
Treated Worst Case (TWC)			414				34	211	659	3763	0.175126	17.5126
Untreated Worst Case (UTWC)			414				34	211	659	3763	0.175126	17.5126

TABLE 8 KEY

Human System Task Category (HSTC) Definitions: Cognitive-Simple: Tasks requiring simple cognitive involvement (low levels of attention, following simple checklists, and not requiring extensive decision making) in conjunction with inputs from other systems. Cognitive-Complex: Tasks requiring complex cognitive involvement (requiring constant attention, frequent interpretation of outside stimuli to inform real-time situations) in conjunction with inputs from other systems. Communication: Tasks requiring primarily communication, via hearing and speaking. Interpersonal Skills: Tasks requiring interpersonal, social interaction between crew including complex technical tasks that require extended crew interaction. Vision: Tasks in which visual information is required. Hearing: Tasks in which primarily auditory information is required, excluding communication, e.g. hearing alarms, medical auscultation, OOHAs. Cardiopulmonary: Tasks requiring greater-than-baseline cardiopulmonary effort, e.g. physically strenuous activities. Dentition: Tasks requiring use of teeth for mastication. GI (Gastrointestinal): Tasks requring use of the alimentary sytem, e.g. solids/liquids consumption and solids excretion. GU (Genitourinary): Tasks requiring use of the male/female genitourinary systems. Hand (Dominant): Tasks performed using primarily the hand, requiring use of the dominant hand (piloting, medical procedures, dental procedures). Hand (Any): Tasks performed using primarily the hand(s), with no preference for dominance, with equivalent bilateral effectiveness. Upper Extremity: Tasks requiring specific use of the upper extremities, excluding hands. Lower Extremity: Tasks requiring specific use of the lower extremities (excluding ambulation and standing in the presence of gravity), e.g. using exercise equipment. Ambulation and Standing (g): Tasks requiring use of both lower extremities to accomplish ambulation or standing in the presence of gravity. Translation and Stabilization (microgravity): Tasks requiring use of either the upper or lower extremities to accomplish translational movement and stabilization (securing oneself to remain stationary) in the setting of microgravity. Don/Doff Equipment: Tasks requiring the donning of personal equipment (including pressure suit, exercise harness, EVA equipment, etc). Pressure Ops: EVA/contingency tasks performed while pressurized in a suit.

Criteria for Assignment of Conditions to HSTCs (any of the following):

1) Is affected crew member physically incapable of performing the human system task category, without impairment, with the condition?
2) Would the treatment (e.g. medications) impair the crewmember's ability to perform the human system task category? (Does not apply to UTx)
3) Does the condition have a high likelihood of causing a significant aeromedical contraindication with an associated human system task category
4) Would performing tasks in an associated task category worsen the condition? (If so, it is affected).
5) Does pain associated with the condition impair any further human system categories?

TASK IMPAIRMENT COMMENTS

CP2: No comment CP3: No comment

EVIDENCE COLLECTION PROCESS

Mesh terms that most closely resembled the best-case and worst-case scenarios, and associated Conditions Included but Not Explicitly Stated (CNES), were utilized to build incidence, duration, RTDC, and LOCL searches by best- and worst-case.

Incidence:

Databases searched for spaceflight and analog incidence data included: PubMed, Google Scholar, NASA Technical Reports Server (NTRS) public search, Defense Technical Information Center (DTIC), and Barratt MR, Baker E, Pool SL. Principles of Clinical Medicine for Space Flight. New York, NY: Springer; 2019. 2nd Edition. Databases searched for terrestrial incidence included: DynaMed, PubMed, and Google Scholar.

Duration, RTDC, LOCL:

Databases searched for duration, RTDC, and LOCL included: Dynamed, Cochrane, PubMed, and Google Scholar. Note, that if duration, RTDC, or LOCL data was found in a DynaMed search, the other search engines were not included. Relevant articles were selected and reviewed. If applicable, the article was included in the CLiFF.

LEVEL OF CONFIDENCE (LOC) SCORING

Articles obtained to update the evidence behind this CLiFF were scored by ExMC editors, based on their applicability to the Exploration Spaceflight environment using the following grading scale:

4 – Confident
3 – Somewhat confident
2 – Neutral
1 – Somewhat unconfident
0 – Not confident

The following considerations factor into the grading scale above:

• How closely does the paper describe the medical condition as defined by the IMPACT 1.0 Condiltion List (relevance)?
• How closely does the population included resemble the astronaut population?
• Quality of the paper (number of subjects, methods, etc.)
• How much does the editor trust the source of the evidence?
• How closely does the editor think that the data represents the exploration spaceflight environment?
• Other considerations, at the discretion of the editor, supported in the comments for LOE scoring.

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ACRONYMS

ACRONYM	PHRASE
AAOMS	American Association of Oral and Maxillofacial Surgeons
AMA	American Medical Association
ARCL	All Remaining Conditions List
ARS	Acute Radiation Sickness
BHP	Behavioral Health and Performance

CAC	Coronary Artery Calcium
CHS	Crew Health and Safety
CL	Condition List
CliFF	Clinical Finding Form
CMO	Crew Medical Officer
COMFORT	Clinical Outcome Metrics for Optimization of Robust Training
CP1	Clinical Phase 1
CP2	Clinical Phase 2
CP3	Clinical Phase 3
CRL	Clinical Resource Level
CRT	Capability Resource Table
CST	Clinical Science Team
DCS	Decompression Syndrome
DRM	Design Reference Mission
ED	Emergency Medicine Doctor
EL	Evidence Library
EMCL	Exploration Medical Condition List
EMT	Emergency Medical Technician
EVA	Extravehicular Activity
EXMC	Exploration Medical Capability
HRP	Human Research Program
ICD	International Classification of Disease
ICL 1.0	IMPACT 1.0 Medical Conditions List
ICU	Intensive Care Unit
IMCL	iMED Condition List
iMED	Integrated Medical Evidence Database
IMM	Integrated Medical Model
IMPACT-MD	Impact Medical Database
IP	Incidence Proportion
IR	Incidence Rate
ISS	International Space Station
IV	Intravenous
JSC	Johnson Space Center
LEO	Low-Earth orbit
LEVA	Lunar Extravehicular Activity
LOCL	Loss of Crew Life
LOM	Loss of Mission
LSAH	Lifetime Surveillance of Astronaut Health
LSO	Lunar Surface Operations
MCL	Master Condition List
MEVA	Medical Extravehicular Activity
NASA	National Aeronautics and Space Administration
N/A	Not Applicable

NP	Nurse Practitioner
OBGYN	Obstetrics and Gynecology
OR	Occurrence Rate
PA	Physician Assistant
PDQ	Pain Disability Questionnaire
PFCL	Proposed Future Conditions List
PPE	Personal Protective Equipment
PTRS	Project Technical Requirements Specification
PRL	Pharmaceutical Resource Level
QTL	Quality Time Lost
RCL	Removed Conditions List
REP	Rochester Epidemiology Study
RTDC	Removal to Definitive Care
SANS	Spaceflight-Associated Neuro-ocular Syndrome
SAS	Space Adaptation Syndrome
SEVA	Spaceflight Extravehicular Activity
SME	Subject Matter Expert
SoP	Standard Operating Procedure
SPE	Solar Particle Event
TBD	To Be Determined
TI	Task Impairment