Clinical Finding Form (CliFF)

Branch	Baseline

ICL101_Sprain/Strain - Back

Back injury usually involves a strain or sprain in the supporting muscles of the vertebral spine, especially common in the lumbar region, and usually involves pain and task impairment. The most common mechanism of injury terrestrially is lifting. The dynamics of this injury are different in microgravity but may occur when a crewmember is translating a high mass object or during regular exercise (Scheuring et al, 2009). A pre-existing history of a significant back injury increases the risk of occurrence on orbit. For the purpose of this CliFF, back sprain/strain injuries are limited to muscles and ligamentous tissue of the back.

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

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 and 31 "back injuries." (Note the 31 back injuries are corroborated by Johnston III et al, 2020). Unfortunately, Scheuring et al, 2009 does not report the number of back sprain/strains specifically. Notably, 9 of the 31 back injuries occurred during exercise on ISS which supports resistance exercise as a risk factor for back sprain/strain in-flight. The IMM version 6.5 2017 update obtained data through ISS Expedition 40 to augment the Scheuring et al, 2009 study. They identified an additional 30 back injuries (3 STS and 27 ISS). These two sources together provide a total incidence of 61 inflight "back injuries" in US spaceflight from Mercury - ISS Expedition 40. This was considered to be the most robust data to inform this CLiFF and was used for the incidence distribution. Note that this may be an overestimate of the incidence because "back injuries" could include injuries beyond sprain/strains, but it was felt to be the best approximation available. Kertsman et al, 2012 is a review of Space Adaptation Back Pain, which is a separate condition that is covered by ICL#91.

ANALOG LITERATURE

Thomas et al, 2003 is a large (n = 13,441) retrospective review of US Navy submarines. The study population consisted of US Navy officers and enlisted men deployed on 240 submarine patrols. This analog is similar to spaceflight in that it is an isolated and confined environment. The subjects are also highly screened, and healthy, similar to astronauts. Unlike astronaut crews, the Navy submariners were all male, 88-90% were white, and most were between 18-35 yo. It provides an incidence of musculoskeletal strains/sprains or 0.7/100 person-years for officers over 30 years old. However, this incidence is not specific to the back.

TERRESTRIAL LITERATURE

Hoy et al, 2012 is a large systematic review of 150 studies spanning 1980-2009 of the global prevalence of low back pain. Search terms included, "back pain, lumbar pain, bach ache, backache, and lumbago." Point, 1 month, 1 year, and lifetime prevalence were than estimated from these studies. Demographics for the populations included in the study were not available but it is clear that it included a large population of elderly patients with back pain.

OVERALL INCIDENCE SUMMARY

INCIDENCE

Mean: 1.367 SD: 0.1774

INCIDENCE SUMMARY

The incidence distribution for this CLiFF is based on 61 documented U.S. in-flight “back injuries” (Scheuring et al, 2009; Johnston III et al, 2020; NASA, Back Sprain/Strain CLiFF, 2017) from Mercury through ISS Expedition 40. This is the Bayesian posterior distribution for the incidence rate given the spaceflight data (61 events over 44.58 person-years of flight) under an uninformative prior is Gamma(shape=59.38, rate=43.44) with mean 1.367 and SD 0.1774.

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
1.36694

SD
0.17739

Gamma
(Shape): 59.38
(Rate): 43.44

TABLE 2. INCIDENCE LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Scheuring et al, 2009	Spaceflight	3
NASA, Back Sprain/Strain CLiFF, 2017	Spaceflight	3
Johnston III et al, 2020	Spaceflight	3
Kerstman et al, 2012	Spaceflight	1
Thomas et al, 2003	Analog	0
Hoy et al, 2012	Terrestrial	0

Scheuring et al, 2009 is a retrospective review of in-flight musculoskeletal events from Mercury - Expedition 13, in which 31 "back injuries" were reported. This is corroborated by Johnston III et al, 2020 in Chapter 10 of Principles of Clinical Medicine for Spece Flight. The IMM Back Sprain/Strain CLiFF updated of 2017 added an additional 30 back injuries to this number, making the value current through Expedition 40. The incidence used for this CLiFF will be the same as the IMM CLiFF from 2017. Kerstman et al, 2012 is a review of Space Adaptation Back Pain (ICL#91), thus not applicable to this condition. Thomas et al, 2003 is analog data from US Navy Submariners, and presents incidence of sprain/strains but is not specific to back sprain/strain. Hoy et al, 2012 presents incidence data for "low back pain" which was assumed to artificially inflate the incidence given that other disorders (e.g. vertebral disc disorder) would be included in this systematic review.

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

Many in-flight back sprain/strain injuries occur during exercise (Scheuring et al, 2009). 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)

None

BEST CASE/WORST CASE PROBABILITY COMMENTS

There is an overall paucity of data regarding the probability of best-case scenario (Grade 1/II) vs. worst-case scenario (Grade III) back sprains/strains. Torjussen and Bahr, 2006 is a review of the 2002-2003 Federation Internationale de Ski Snowboard World Cup snowboard accidents. 135 acute injuries occurred, the most common of which was sprains/strains and 13% of injuries occurred to the back. The injuries were graded using the Abbreviated Injury Scale (AIS) as 1 (minor), 2 (moderate), 3 (severe, not life threatening, 4 (serious, life threatening), 5 (critical, survival uncertain), 6 (maximum, currently untreatable). All back injuries were scored as AIS 1 or 2. This approximates to a 100% best-case scenario. The 2017 IMM CLiFF had a best-case probability of 97-98% and a worst-case probability of 2-3%, based on a worst-case scenario definition of "severe back injury accompanied by severe pain." This was based on an algorithm developed with the original IMM, not informed by data. Therefore, both of these sources were considered and the best-case scenario probability was assigned as 97-100% and the worst-case scenario probability was assigned as 0-3%.

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

Citation	Source	LOC Value
Torjussen and Bahr, 2006	Terrestrial	2
NASA, Back Sprain/Strain CLiFF, 2017	Spaceflight	2

Torjussen and Bahr, 2006 is a review of the 2002-2003 Federation Internationale de Ski Snowboard World Cup snowboard accidents. 135 acute injuries occurred, the most common of which was sprains/strains and 13% of injuries occurred to the back. The injuries were graded using the Abbreviated Injury Scale (AIS) as 1 (minor), 2 (moderate), 3 (severe, not life threatening, 4 (serious, life threatening), 5 (critical, survival uncertain), 6 (maximum, currently untreatable). All back injuries were scored as AIS 1 or 2. This approximates to a 100% best-case scenario. The 2017 IMM CLiFF had a best-case probability of 97-98% and a worst-case probability of 2-3%, based on a worst-case scenario definition of "severe back injury accompanied by severe pain." This was based on an algorithm developed with the original IMM, not informed by data.

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: 1.367 SD: 0.1774	97 - 100	100	0.87	17.1937	24	336	0	0	0	0	0
Treated Worst Case (TWC)		0 - 3	100	2.2	44.5952	730	11680	39.2506	0	0	0	0
Untreated Best Case (UTBC)	N/A	N/A	N/A	0.87	44.5952	72	672	0	0	0	0	0
Untreated Worst Case (UTWC)	N/A	N/A	N/A	2.2	46.8243	730	11680	39.2506	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 best-case scenario RTDC probabilities were pre-determined to be 0% by the Clinical & Science Team of ExMC. The RTDC surrogates assigned for the worst-case scenarios were need for surgery and/or hospitalization. See detailed comments for each scenario below.

TREATED BEST CASE (TBC) SCENARIO COMMENTS

The duration is based on non-specific acute low back pain studies. The minimum duration (24 hours) is informed by Carey et al, 1996 as this was the minimum duration necessary to meet criteria for "severe low back pain that leads to the respondent's being unable to perform his or her usual daily activities for at least one day." The maximum duration of 336 hours (2 weeks) is also based on Carey et al, 1996 in which the majority of patients with low back pain did not present for care and had resolution within 2 weeks. RTDC probability for best-case scenarios was pre-determined by the ExMC Clinical & Science Team to be 0%. There was no evidence in the literature to support LOCL from a back strain/sprain. LOCL was accordingly assigned a probability of 0%.

TREATED WORST CASE SCENARIO (TWC) COMMENTS

There is a paucity of data in the literature regarding Grade III sprains/strains of the back. Available literature focuses primarily on the latissimus dorsi in high performance athletes. The best summary of this is a review of 55 cases of latissimus dorsi and teres major ruptures. This review includes 23 cases of latissimus dorsi rupture (11 were treated operatively). All returned to near preinjury function. The range of healing time was 1 month to 16 months for operative cases (Donohue, 2017). 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 executive 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%. There was no evidence in the literature to support LOCL from a back strain/sprain. LOCL was accordingly assigned a probability of 0%.

UNTREATED BEST CASE (UTBC) SCENARIO COMMENTS

Derry et al, 2017 included a placebo arm for treatment of "acute low back pain" secondary to sprains/strains. These resolved within 3-14 days. The duration was accordingly assigned as 72-672 hours. RTDC probability for best-case scenarios was pre-determined by the ExMC Clinical & Science Team to be 0%. There was no evidence in the literature to support LOCL from a back strain/sprain. LOCL was accordingly assigned a probability of 0%.

UNTREATED WORST CASE (UTWC) SCENARIO COMMENTS

There is a paucity of data in the literature regarding Grade III sprains/strains of the back. Available literature focuses primarily on the latissimus dorsi in high performance athletes. The best summary of this is a review of 55 cases of latissimus dorsi and teres major ruptures. This review includes 23 cases of latissimus dorsi rupture (11 were treated operatively). All returned to near preinjury function. The range of healing time was 1 month to 13 months for non-operative cases and 1 month to 16 months for operative cases (Donohue, 2017). While it is plausible that operative intervention could extend healing times, for consistency's sake within the CLiFF, the 1-16 months (operative intervention) duration will be used again for this scenario. 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 executive 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%.There was no evidence in the literature to support LOCL from a back strain/sprain. LOCL was accordingly assigned a probability of 0%.

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

Citation	Source	LOC Value
Carey et al, 1996	Terrestrial	3
Donohue et al, 2017	Terrestrial	

Citation	Source	LOC Value
Derry et al, 2017	Terrestrial	

Durations are informed primarily by literature regarding "acute low back pain" rather than specifically back sprain/strain, but the durations were felt to be reasonable for this diagnosis based on ExMC SME editor review.

TABLE 6. RTDC LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Chesson et al, 1988	Analog	3
Donohue et al, 2017	Terrestrial	

The Clinical & Science Team of ExMC pre-determined that RTDC probability for best-case scenarios is 0%. For worst-case scenarios, the surrogates of hospitalization and surgery were considered.

TABLE 7. LOCL LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
N/A	N/A	3

No literature was identified to suggest that LOCL is an outcome of back sprain/strain for any scenario. Thus the probability was assigned 0% for all scenarios.

CAPABILITY RESOURCE TABLE (CRT) OVERVIEW

Capabilities and Resourcing Scope Overview Sprain/strain – Back encompasses sprains or strains of any of the muscles of the back (exclusive of the neck musculature). Best-case scenario involves Grade I/II sprains/strains and worst-case scenario involves Grade III sprains/strains. CNES: N/A Diagnostic Scope and Resourcing In the best-case scenario, diagnosis is based on history, physical examination (musculoskeletal, neurologic). In the worst-case scenario, diagnosis is based on history, physical examination (musculoskeletal, neurologic, ano-rectal examination). Musculoskeletal ultrasound may serve as a useful adjunct to rule out other pathologies in the differential diagnosis but was not considered essential to diagnosis. The utility of musculoskeletal ultrasound would be determined on a case-by-case basis. It was included as a non-necessary capability. This diagnostic framework is consistent with the terrestrial workup for back sprain/strain 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): 0.87 hours CP1 WC (Treated or Untreated: 2.2 hours This CRT includes a scope of practice code of 5 (which correlates to an “Experienced procedure trained generalist attending (ED attending)” and was included for musculoskeletal ultrasound and interpretation. Treatment Scope and Resourcing Terrestrially, back sprains and strains resolve quickly with a period of relative rest, analgesia, and physical therapy. Exercise modification is also recommended, but not built into the CRT as this does not represent a clinical resource. Pain is variable depending on the patient. NSAIDs (both oral and topical), cold packs, lidocaine patches, and acetaminophen were included in the best-case treatment scenario, muscle relaxing agents were additionally included in the worst-case scenario. Although 3D printing offers potential for splinting of musculoskeletal injuries, it remains a largely experimental process and it is not within the scope of this CRT. Communications and Support Needs While real-time video and audio loop communications are desired for diagnosis and treatment, they were not considered a necessity. REFERENCES 1. Oliveira CB, Maher CG, Pinto RZ, Traeger AC, Lin C-WC, Chenot J-F, et al. Clinical practice guidelines for the management of non-specific low back pain in primary care: an updated overview. Eur Spine J 2018; 27:2791–803. 2. Low Back Pain. Retrieved 9 December 2020 from https://www.aafp.org/family-physician/patient-care/clinical-recommendations/all-clinical-recommendations/back-pain.html

IMM CLIFF RECONCILATION COMMENTS

The best and worst-case scenario definitions have changed. Previously the IMM best-case scenario definition was, “mild or moderate back injury which resolves by itself or causes minimal disturbance requiring only symptomatic treatment.” The current best-case scenario definition is, “A Grade I or II strain/sprain in which there is minimal or partial muscle or ligamentous tearing.” The IMM worst-case scenario definition was, “having a severe back injury accompanied by severe pain.” The current worst-case scenario definition is, “A Grade III strain/sprain in which there is full thickness muscle or ligamentous tearing, and/or instability.” The updates to these definitions were made to standardize the best and worst-case scenario definitions for sprains/strains across all sprain/strain conditions in the ICL 1.0. Despite their differences, the current definitions would manifest in symptoms that are similar to the IMM definitions. The incidence from the 2017 version 6.5 update to the IMM was used again in this CLiFF as it was the most robust and accurate representation of in-flight back sprain strain incidence data available.

LIMITATIONS SUMMARY

• The incidence for this condition is based on spaceflight data regarding inflight “back injuries.” While the vast majority of these can be assumed to be sprains/strains, it is not explicitly specific to back sprain/strain injuries. • There is a paucity of data to inform the best-case, worst-case probabilities for this condition. The values used in this CLiFF were based on a study in elite snowboarders (Torjussen and Bahr, 2006) and the prior IMM CLiFF (NASA, Back Sprain/Strain CLiFF, 2017). • The duration values are based primarily on studies regarding “acute low back pain” rather than specifically back sprain/strain.

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)		664										
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)			414	22				211	647	3763	0.171937	17.1937
Untreated Best Case (UTBC)	132		414	22	196		34	211	1673	3763	0.444592	44.4592
Treated Worst Case (TWC)	132		414	22	196		34	211	1673	3763	0.444592	44.4592
Untreated Worst Case (UTWC)	132		414	22	196		34	211	1762	3763	0.468243	46.8243

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)		664										
Untreated Worst Case (UTWC)		664										
	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)	132		414	22			34	211	1477	3763	0.392505	39.2506
Untreated Worst Case (UTWC)	132		414	22			34	211	1477	3763	0.392506	39.2506

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: The majority of impairment from all sprain/strain-type injuries stems from uncontrolled pain. 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