Clinical Finding Form (CliFF)

Branch: Baseline

ICL31_Dental Fracture/Exposed Pulp

Pulpitis is an inflammation of the dental pulp resulting from untreated caries, trauma, or multiple restorations. Its principal symptom is pain. Pressure necrosis frequently results from this form of exposed pulp and can be complicated by persistent pain and periapical abscess. (Merck Manual, 2008) Due to required dental examinations and care before flight, untreated caries is an unlikely etiology. A more likely mechanism on orbit would be due to damage to pre-existing restorations or dental trauma. Treatment is available on orbit with topical and systemic analgesics, instruments in a toothache kit (Red Cross, and antibiotics. (International Space Station Integrated Medical Group, 2006)

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

Menon's review of dental injuries showed an incidence of conditions that could lead to pulpitis as 0.015 events per person-year with the IMM model predicting that the rate of dental exposed pulp was 0.021 events per person year and the incidence rate of exposed pulp was 0.02%. Zaitsu's review article studied Space and Antarctic environments and found 0.02 events of exposed pulp/pulpitis per person years.

ANALOG LITERATURE

Excellent analog study was done in Nepal by surveying trekkers. They had 309 completed survey and found that the incidence of a tooth fracture was 1:509 trekking days. The researchers also calculated that in 2007, there were a total of 903,550 total days of tourists, and an estimation of 1700 tooth fractures. Fracture and/or loss of dental restoration: 48/1317 (3.6%). Tooth fracture: 11/1317 (0.8%). Chaffin, 2008 was the historic citation provided to this project-- decent stratification of dental injuries for soldiers deploying for stabilization to Bosnia.

TERRESTRIAL LITERATURE

Incidence of traumatic dental injuries is approximately 1%-3% with the highest incidence among children aged 12 years. Children and adolescents comprise a disproportionally higher number of traumatic dental injuries, approximately 18%-20%. Boys tend to be at higher risk of injuries compared with girls, and children who are higher risk takers tend to have repeated dentoalveolar trauma.

OVERALL INCIDENCE SUMMARY

INCIDENCE

mean 0.0211 and SD 0.002714

INCIDENCE SUMMARY

The Bayesian posterior distribution for the incidence rate, given the Analog reference data (SFOR VII and VII), under an uninformative prior is Gamma(shape=60.443, rate=2864.6) with mean 0.0211 and SD 0.002714.

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
0.0211
SD
0.00271399

Gamma
(Shape): 60.443
(Rate): 2864.6

TABLE 2. INCIDENCE LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Menon, 2012	Analog	3
ZAITSU, 2010	Analog	2
Küpper, 2014	Terrestrial	2
Gunepin, 2015	Terrestrial	2
Chaffin, 2008	Terrestrial	2
Reddy, 2019	Terrestrial	2

The data in spaceflight is very weak. All the work is based on the IMM model that was used for the original CLiFFs. The analog data is fairly similar (0.015 vs 0.02) so a combination or simply using the analog (actual) data may be preferred given its actual relevance in the spaceflight population (selected and preselected crew).

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

Extensive dental exam is performed at L-90/30 days. All dental hardware is verified and removed or reattached as appropriate. A full dental orthopantomogram x-ray or full mouth x-ray series is performed within two years of launch to fully assess the underlying dental health of the Crewmember in order to correct any potential dental problems well in advance of mission launch.

BEST CASE SCENARIO DEFINITION

Reversible pulpitis, (pain is controlled by removing the painful stimuli, oral pain reliever, sensitive toothpaste, or by topical anesthetic) OR a fractured tooth (non-crowned) limited to enamel or dentin exposure (not involving the pulp or root).

WORSE CASE SCENARIO DEFINITION

Irreversible pulpitis, or fractured tooth (non-crowned) involving the pulp or root, that requires oral pain medications and/or injected analgesic.

CONDITIONS INCLUDED, BUT NOT EXPLICITLY STATED (CNES)

None

BEST CASE/WORST CASE PROBABILITY COMMENTS

Data from space medicine citations below. The IMM used a 79%/21% split based on a study (Krell KV, Rivera EM. A six year evaluation of cracked teeth diagnosed with reversible pulpitis: treatment and prognosis. J Endod 2007 Dec;33(12):1405-7). It is reasonable to continue with the 75%/25% split as noted by the original data but consideration could be made to skew slightly more toward a best case scenario as the original IMM data has done

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

Citation	Source	LOC Value
Menon, 2012	Analog	3
ZAITSU, 2010	Analog	2

Inflammed pulp 0.015 events per person-year. Exposed pulp 0.0201 events per person year. Incidence rate of 0.02% for pulpitis for IMM model.

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 0.0211 and SD 0.002714	75 - 75	100	1.083	0	0	1	0	0	0	0	0
Treated Worst Case (TWC)		25 - 25	100	1.083	13.4467	0	3	0	0	1.42	0	0
Untreated Best Case (UTBC)	N/A	N/A	N/A	1.083	26.8934	0	1	26.8934	0	0	0	0
Untreated Worst Case (UTWC)	N/A	N/A	N/A	1.083	38.1876	1.5	168	38.1876	0	1.42	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

ASSUMPTION: for WC definition, 'irreversible pulpitis,' we acknowledge that definitive care is endodontic therapy. But there is debate on the time sensitivity for this procedure, and we elected to not use for a surrogate for RTDC (i.e. = 100%). Generally this condition can be seen as benign, although there is some risk of RTDC and LOCL with it. RTDC states 'intractable pain,' which is hard to isolate in the literature to meet criteria for debilitating and mission ending. UT disease is sadly, well documented in global health/public health surveys, but this leads to a smoldering chronic periodontal disease which doesn't advance understanding of our desired data points. LOCL is highly unlikely BUT is cited in the literature (undoubtedly, albeit poorly characterized, by significant comorbidities).

TREATED BEST CASE (TBC) SCENARIO COMMENTS

DynaMed and Cochrane had no valuable information about BC scenario for Pulpitis (reversible). This is likely because reversible pulpitis is transient and lasts only a couple seconds once the stimulus is removed. There was more information available regarding BC scenario for Dental Fractures (not invloving pulp). This information was included in the Duration in Hours tab. Additionally, BC scenario for (reversible) Pulpitis and Dental Fractures (not involving the pulp) will not result in RTDC or LOCL. However, dental consultation is preferred for Dental Fractures (not involving the pulp) but do not present a threat to the crewmember's life.

TREATED WORST CASE SCENARIO (TWC) COMMENTS

DynaMed and Cochrane both did not provide any valuable management recommendations or review articles regarding WC scenario for Pulpitis (exposed pulp/irreversible). We know the Irreversible Pulpitis can linger for minutes after an inciting stimulus and can last for several days until the pulp is necrosed and the patient cannot feel the pain anymore. With regard to WC scenario for Dental Fractures (involving the pulp) this requires emergent dental referral and tooth restoration by a dentist within 3 hours in order to ensure tooth survival. We have attributed a very small % of RTDC and LOCL to this WC condition based on assumptions of chonic, intractible pain [see Tab 4D assumptions] and evidence of mortaility-- with significant limitations-- in the literature.

UNTREATED BEST CASE (UTBC) SCENARIO COMMENTS

In the best case scenario, untreated reversible pulpitis may progress into irreversible pulpitis. This process can take years to develop so the rate at which this can happen is largely dependent on the frequency of reversible pulpitis symptoms prior to departure for the mission. A BC scenario dental fracture in the acute setting, if left untreated will not be harmful to the crewmembers ability to complete their mission, as long as adequate analgesia is achieved. Typically mild analgesics suffice.

UNTREATED WORST CASE (UTWC) SCENARIO COMMENTS

Information regarding UTWC Duration was pulled from the old CLiFF for this condition. The previous CLiFF did not have a citation to reference for it's information. The UTWC RTDC was based off of the likelihood that the tooth would become nonvital or necrosed - as this would necessitate endodontic treatment and removal. Therefore, my assumption on this condition duration are that after one week of pulpitis, crew are likely to pull the tooth on their own rather than be subjected to continued pain from infection and inflammation. It is unlikely that a crewmember would be willing to stay in pain based solely on the principle that we are unable to treat them with limited medical supplies on hand and would likely create a makeshift treatment, such as using pliers to remove the infected tooth. When looking through the literature I did not find anything regarding loss of life related to pulpitis or dental fracture/tooth loss without confounding comorbilities such as coronary artery disease and atherosclerosis or valvular disease. RTDC was based on incidence of aveolar osteitis as a surrogate for intractible pain-- understanding this is likely an overestimation. LOCL has an extraordinarily low but present LOCL-- likely confounded with comorbidities.

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

Citation	Source	LOC Value
DynaMed, 1995	Terrestrial	2
DynaMed, 1995	Terrestrial	
Ajayi, 2010	Terrestrial	

Cochrane did not have many review articles regarding pulpitis (only 2). These artcles looked at the effect of antibiotics on pain and the use of different local anesthetic prearations during dental procedures. Individuals with a Dental Fracture that involves the pulp require emergent dental

referral for tooth restoration by a dentist within 3 hours of the incident in order to ensure the best chance of healing. They can also receive analgesics and temoporary filling material but neither is a substitute for dental referral. Reversible pulpitis lasts 1-2 seconds and Dental Fractures Class I and II can be treated without analgesia.

TABLE 6. RTDC LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Walls, 2017	Terrestrial	2
Øyri, 2020	Terrestrial	
Yates, 1992	Terrestrial	

Management and Prognostic data in DynaMed referenced in (Rosen's Emergency Medicine: Concepts and Clinical Medicine) it did not provide demographic data or a number of people included in studies. The management and prognosis sections of the textbook, related to this topic did not have any additional references to further examine demographics. Most chonic pain syndromes necessitating followup surgery are cited as aveolar osteitis, particularly of the molars. There is a paucity of literature describing irreversible pulpitis or fractured tooths (WC definition) as emergent interventions for pain, as opposed to viability. Most debilitating facial pains are cited as trigeminal neuralgia, not thought to be odontogenic in nature; post operative; or from cancer treatments. We have cited aveolar osteitis as the high maximum (1.42% but this was after oral surgery, i.e. the absolute worst case) for RTDC, although the incidence is likely much lower [risk factors associated with dry socket were lower teeth, molars, female gender, and patients with inadequate oral hygiene.] By the very definition of being "best case" this will be a self limited condition without need for escalation. Adding to (Kruger-Claassen), (Yates, 1992) cited a popultion aged 11-20 with root-fractures of permanent incisors. They followed these teeth for 2-31 years. 41% manifested a WC scenario where disease state progresses into a nonvital tooth. At this point, definite treatment is needed to extract the tooth. Yet no tooth became abscessed or developed a sinus tract, and resorption of bone at the fracture line was observed in only one out of five non-vital teeth. Lack of displacement and placing of a splint increased the chances of the pulp remaining vital and healing of the fracture occurring with hard tissue. Sclerosis of the coronal pulp occurred mainly when healing was by connective tissue. The apical pulp always remained vital, and there was sclerosis of the apical pulp in almost every case. Yet although there was demonstrable odontogenic disease in this population, there was no definitive need for hospitalization or debilitating, intractible pain documented.

TABLE 7. LOCL LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Kruger-Claassen	Terrestrial	2
Nalliah, 2011	Terrestrial	

Management and Prognostic data in DynaMed referenced via Emergency Medicine textbook (Rosen's Emergency Medicine: Concepts and Clinical Medicine) it did not provide demographic data or a number of people included in studies. The management and prognosis sections of the textbook, related to this topic did not have any additional references to further examine demographics. Additionally, the references in DynaMed for complications associated with Dental Fractures were not prospective or retrospective studies that examined groups of individuals to provide their informaiton. Lastly, Cochrane did not provide any relevant review articles on the topic of Pulpitis to help locate this type of data. Demographics included US citizens that presented to the ED with pupal or periapical diseases. The average age of the patients were 32.9 years. Most were of a lower income bracket and uninsured. Of all the patients, 5,721 (1.4%) were admitted to the hospital for an average of 2.95 days. Mortality was notattributible to pulpitis or tooth fracture, and no searches yieled definitive linkage of this disease to mortality without significant comorbidities. Populations for the permanent teeth included abover were from adults and adolescents (with permanent teeth) that were either in vivo or in vitro, traumatized, and vital. There was no explicit data on LOCL from Irreversible Pulpitis or Dental Fracture. The 0.0025% represents the death rate related to pupal or periapical disease in the US in 2006 for patients seen in the ED with routine treatment, although many had comorbidities. There was no explicit data on LOCL or death from Irreversible Pulpitis or Dental Fracture.

CAPABILITY RESOURCE TABLE (CRT) OVERVIEW

Overview

Dental fracture is a common complication during a traumatic event that may injure more than just the teeth. However, all other injuries, including other dental injuries, are beyond the scope of this CLiFF. There are multiple types of fractures that can occur in the tooth and involve various layers of the tooth. The worst-case scenario in this CLiFF involves a fracture that extends beyond the enamel and dentin and the pulp becomes exposed. After this injury, there can be pain with chewing/biting, cold/heat intolerance with liquids/food, and random pain. Furthermore, complications include discoloration, pulp canal obliteration, pulp necrosis, repair-related resorption, infection-related resorption, ankylosis-related resorption, or premature tooth loss, and thus treatment is aimed at mitigating these complications.

CNES: None

Diagnostic Scope and Resourcing

In the best-case scenario, diagnosis is based on history and physical examination (limited dental exam including bite testing). X-rays, mobility testing, and pulp vitality testing will be unavailable inflight. In the worst-case scenario, these diagnostic capabilities and limitations are identical.

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): 1.083 hours
CP1 WC (Treated or Untreated): 1.083 hours

The highest scope of practice for diagnosis is 4 (intern/PA/NP).

Treatment Scope and Resourcing

Terrestrial treatment options following dental facture in general may include monitoring, covering with calcium hydroxide and/or dental cement, crown placement, dental veneer, root canal, extraction, and/or installation of a prosthesis. In the best-case scenario in spaceflight, the cornerstones of management are going to revolve around symptom control such as pain control and bleeding control. Mild dental bleeding can be managed with cotton balls/swabs and gauze. Pain management may be acutely treated with gauze, topical lidocaine with epinephrine, and with treatment with oral NSAIDs and Tylenol. Depending upon the depth of the fracture, calcium hydroxide and/or dental cement may be used in spaceflight if available. Inflammation and infection prophylaxis of the dental socket should be managed with demeclocycline/triamcinolone topical if available as this may mitigate the risk of infection-related resorption and pulp necrosis. Alternatives can include triamcinolone topical and chlorhexidine topical if it is not available. Though these are much less likely to be utilized terrestrially, during spaceflight, the typical management by dental teams will not be available and more liberal use of pharmacologic modalities may be necessary.

In worst-case scenarios where there is moderate to severe pain or fracture that is involving the pulp or the root, more resources are required. It is possible that irrigation equipment, oral sutures, tranexamic acid, and gingival anesthesia may also be necessary. Even a dental nerve block could be performed with bupivacaine and epinephrine. Further, oral narcotics may also be needed for a short duration in addition to NSAIDs and Tylenol. Lastly, infection prophylaxis with oral amoxicillin or clindamycin can be considered in certain worst-case scenarios. The remainder of the treatment options remain the same. While dental extraction can be performed if necessary, crown placement, dental veneer, root canal, or further endodontic treatment will not be possible.

Communications and Support Needs

While real-time video and audio loop communications are desired for diagnosis and treatment, they were not considered a necessity, particularly in the best-case scenario. For the WC, consultation with ground specialists to facilitate treatment and healing was considered necessary given the limited diagnostic and treatment capabilities in-flight.

IMM CLIFF RECONCILATION COMMENTS

Incidence rate is based on analog population data (Chaffin, 2008). Best case and worst case definitions for the LD68 CliFF and Evidence Library Condition List are very similar.

LIMITATIONS SUMMARY

It was very difficult to find any terrestrial studies that accurately reflect the incidence of this condition during spaceflight conditions. Studies that reported incidence of tooth fractures grossly overestimate the risk to astronauts in microgravity. Studies reporting pulpitis are also likely to be overestimates, as well, due to the meticulous dental care that astronauts receive prior to missions. Thus, computing the incidence using terrestrial studies that investigated pulpitis alone was thought to be the best estimate of the combined incidence of pulpitis and fractures. Because of the large sample size, the studies used to compute the composite incidence most likely overestimate the confidence we have in the assigned value. Under-reporting for this condition could have been significant during past space missions due to subtle disease that may not have been apparent to the crew. This may result in underestimation of the incidence.

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						5				
Treated Worst Case (TWC)		664						5				
Untreated Worst Case (UTWC)	223	664	113	89				5				

	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)	132							211	1012	3763	0.268934	26.8934
Treated Worst Case (TWC)	132							211	1012	3763	0.268934	26.8934
Untreated Worst Case (UTWC)	132							211	1437	3763	0.381876	38.1876

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)		664						5				
Treated Worst Case (TWC)												
Untreated Worst Case (UTWC)	223	664	113	89				5				

	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)	132							211	1012	3763	0.268934	26.8934
Treated Worst Case (TWC)									0	3763	0	0
Untreated Worst Case (UTWC)	132							211	1437	3763	0.381876	38.1876

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