Clinical Finding Form (CliFF)

Branch	Baseline

ICL34_Dislocation - Shoulder

The shoulder is the most mobile joint in the body. The shoulder's integrity is maintained by the glenohumeral joint capsule, the cartilaginous glenoid labrum (which extends the shallow glenoid fossa), and muscles of the rotator cuff. Anterior dislocations occur in as many as 95% of cases. Posterior dislocation occurs in 2-4% of dislocations. Inferior dislocations are very rare. Shoulder dislocations are the most common joint dislocation seen in emergency departments in the United States. Symptoms include sever pain and limited range of motion. (Harvard Health, 2019) Shoulder dislocations can be associated with damage to surrounding tissues (fractures, labral tears, and neurovascular injuries).

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

There are no published occurrences of shoulder dislocation in United States spaceflight missions.

ANALOG LITERATURE

There are few epidemiology studies of shoulder dislocation in space analog or wilderness environments. The best analog studies found were from the U.S. military, a group with relatively similar demographics and baseline health as the astronaut population. Two studies found similar incidence if shoulder dislocation among active duty military: 169 per 100,000 person-years (Owens et al 2009) and 207 per 100,000 person-years (Brewster et al, 2008). This incidence rate is more than 10 times that of the general population based on terrestrial data. This is likely due to military training and operations activities that increase the risk of shoulder injuries above that of the general population. Some astronaut activities, such training for EVA in the Neutral Buoyancy Lab, are prone to shoulder injuries (sprains/strains/labral injuries, but not dislocation) and astronauts are generally more physically active than the general population. Despite this, there is no evidence that astronauts are more likely to sustain shoulder dislocations than the general population. Astronaut training and operations are assumed to be lower impact activities than military training, making the military studies less applicable than the terrestrial data to the astronaut population.

TERRESTRIAL LITERATURE

Zacchilli and Owens, 2010 identified shoulder dislocations through a database of United States emergency department medical records from 2002-2006 comprising of a sample size greater than 8000 shoulder dislocations. The average age at diagnosis was 35.4 years, but the paper included all ages. The overall incidence was 23.9 / 100,000 person-years, but results were stratified by both age and sex, providing the opportunity for age-adjustment for an incidence value that is more applicable to the astronaut population. Simonet et al, 1984 similarly used medical records from all hospitals serving Olmstead County, Minnesota (Rochester Epidemiology Project) from 1970-1979 comprising a sample size of 116 patients (telephone interviews were conducted). These data are now between 40-50 years old. Simonet et al also included all ages, with an average age of diagnosis in the mid-30s. The overall incidence of these data was 8.2 / 100,000 person-years. These data were also stratified by age and sex, allowing for use of age-adjusted rates.

OVERALL INCIDENCE SUMMARY

INCIDENCE

mean 1.34E-07 SD 7.87E-09

INCIDENCE SUMMARY

Surface-ops EVA condition with incidence distribution Beta(shape1=289, shape2=2160262527) which has mean 1.338E-7 and SD 7.87E-9 (95%CI: 1.19E-7, 1.497E-7). This represents the posterior distribution for the age-adjusted (matching to flown astronauts) incidence rate under an uninformative prior. The posterior samples of the incidence rate are used to generate a posterior distribution for the probability of experiencing at least one shoulder dislocation over a 6-hour surface-ops EVA. The analysis is based on a terrestrial study of shoulder dislocations, which reports age-specific (10 year groupings) incidence rates and confidence limits.

TABLE 1. INCIDENCE MODEL

Incidence Details

Incidence Type
EVA

Segment
EVA Surface

Env. Exposure
NA

Sex
Any

Crowns
Any

Contacts
Any

Pregnancy
Any

Incidence Distribution

Occurrence Dist
Binomial

Incidence Dist.
Beta

Mean
1.34E-07

SD
7.87E-09

Beta
(Alpha): 289
(Beta): 2.16026E+09

TABLE 2. INCIDENCE LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Zacchilli and Owens, 2010	Terrestrial	3
Simonet et al, 1984	Terrestrial	3
Owens et al, 2009	Analog	2
Brewster et al, 2008	Analog	2

Zacchilli and Owens, 2010 identified shoulder dislocations through a database of United States emergency department medical records. Simonet et al 1984 similarly used medical records from all hospitals serving Olmstead County, Minnesota (Rochester Epidemiology Project). Both provided age and gender stratification of the results. Neither study was explicit about how dislocations were diagnosed (although Simonet et al specified that posterior dislocations and fractures other than minor avulsions were excluded). It was assumed that standard of care was followed and dislocations were confirmed radiographically. The incidences reported by these two studies are notably different. Both studies included all patients (including children) with shoulder dislocations, with average ages in the mid-30s. (The average age of the astronaut population is somewhat higher than this). However, it is felt that the terrestrial data is more representative of shoulder dislocations in the astronaut population than the military analog data (Owens et al and Brewster et al) which present significantly higher incidences of shoulder dislocation.

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

There are no preventive measures, required of crewmembers, specific to shoulder dislocation.

BEST CASE SCENARIO DEFINITION

A shoulder dislocation that is easily reduced, requires immobilization for less than a week, and does not recur.

WORSE CASE SCENARIO DEFINITION

A shoulder dislocation that meets any of the following criteria: requires sedation for reduction, results in persistent pain despite reduction, recurs, cannot be reduced, results in neurovascular compromise, or requires surgery.

CONDITIONS INCLUDED, BUT NOT EXPLICITLY STATED (CNES)

None

BEST CASE/WORST CASE PROBABILITY COMMENTS

Recurrent dislocation was considered to be the most common of the outcomes listed in the worst-case scenario and thus the most appropriate surrogate. Simonet el al, 1984 provided an approximate 40% rate of recurrent dislocation. However, this is not representative of the astronaut population because risk of recurrence varies by age - young people (< ~30yo) have the highest risk of recurrence (because their dislocations are more often associated with instability), whereas risk is lower after age ~30. The Simonet et al population was younger than the control "referral" population that it was compared to. This control referral population had a recurrence rate of 24.5%. Hovelius et al reports a 27% recurrence rate in those age 30-45 in a 25yr follow-up study (most occur in the first ~6mo). Paterson et al, 2010 (meta-analysis) report values ranging from 6-29% recurrence in patients age 30 and older (mean 21%, median 23%). Given meta-analysis data is available, the value of 23% from Paterson et al, 2010 has been assigned as the worst-case probability.

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

Citation	Source	LOC Value
Simonet et al, 1984	Terrestrial	3
Hovelius et al, 2008	Terrestrial	3
Paterson et al, 2010	Terrestrial	4

Simonet el al, 1984 provided an approximate 40% rate of recurrent dislocation. However, this is not representative of the astronaut population because risk of recurrence varies by age - young people (< ~30yo) have the highest risk of recurrence (because their dislocations are more often associated with instability), whereas risk is lower after age ~30. The Simonet et al population was younger than the control "referral" population that it was compared to. This control referral population had a recurrence rate of 24.5%. Hovelius et al reports a 27% recurrence rate in those age 30-45 in a 25yr follow-up study (most occur in the first ~6mo). Paterson et al, 2010 (meta-analysis) report values ranging from 6-29% recurrence in patients age 30 and older (mean 21%, median 23%).

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 1.34E-07 SD 7.87E-09	77 - 77	100	1.37	19.333	24	720	0	0	0	0	0
Treated Worst Case (TWC)		23 - 23	100	1.45	19.333	2016	2880	0	10	48	0	0
Untreated Best Case (UTBC)	N/A	N/A	N/A	1.37	31.7699	24	720	21.0205	0	0	0	0
Untreated Worst Case (UTWC)	N/A	N/A	N/A	1.45	55.3415	2016	2880	21.0205	10	48	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

RTDC surrogate searches included: permanent disability, nerve injury, and vascular compromise. See specific comments for each scenario below.

TREATED BEST CASE (TBC) SCENARIO COMMENTS

Watson et al 2016 was used for duration. This is a review article for return to play protocols for young athletes with anterior shoulder dislocation. The study included 30 athletes, age range is 14-20 (average 16.5) with mix of genders, and incorporated information from prospective NCAA athletes as well. The authors reported that most athletes return to sports 2-3 weeks after injury, citing range of 0 to 30 days. The assumption was made that astronauts would not return to work immediately, and would be immobilized for a minimum of 1 day. The RTDC probability for a best-case scenario shoulder dislocation was pre-determined by the Clinical & Science Team to be 0%. No literature review was performed for RTDC and a 0% probability was assigned. A Dynamed search for "Shoulder Dislocation" revealed three studies (Zacchilli and Owens, 2010; Simonet et al, 1984; and Hovelius, 1982). These studies indicated an LOCL probability of 0% so the assumption was made for this scenario (and all other shoulder dislocations based on this search) that LOCL probability was 0%.

TREATED WORST CASE SCENARIO (TWC) COMMENTS

Duration for the worst-case treated scenario was derived from two articles describing rehabilitation protocols for shoulder dislocations with gradual return to duty, sports, and activities. Kirkley et al, 2005 was a Canadian study of 40 male, skeletally mature subjects, under age 30, comparing immobilization treatment to arthroscopic stabilization for 5 years of follow-up. Bottoni et al, 2002 followed a group of 24 military patients at Tripler Army Hospital in Hawaii. 14 were treated non-operatively for acute, traumatic, first-time shoulder dislocation and the remaining 10 were treated operatively with a Bankart repair. They were followed for an average of 36 months. Patients ranged from age 18-26. Surrogates for RTDC were permanent disability, vascular injury, and nerve injury. Three articles informed a RTDC probability of 10% based on risk of vascular and nerve injury complications associated with shoulder dislocation (Cutts et al, 2009; Stayner et al, 2000; and Visser et al, 1999). Cutts et al is a review article that reports a lower bound of nerve injury as an axillary nerve injury rate of 10%. Stayner et al was a review article for shoulder dislocations in patients over the age of 40, and presents a risk of vascular injury of 1-2%. Visser et al reviewed nerve injuries as a result of shoulder dislocation in a small population (n = 77) with an average age of the population of 52.3 years and reports a 48% risk of nerve injury based on EMG studies, with the majority resolving after 12-45 weeks. Stayner et al and Visser et al have more appropriate age ranges to apply to the astronaut population than those used for the duration values. A Dynamed search for "Shoulder Dislocation" revealed three studies (Zacchilli and Owens, 2010; Simonet et al, 1984; and Hovelius, 1982). These studies indicated an LOCL probability of 0% so the assumption was made for this scenario (and all other shoulder dislocations based on this search) that LOCL probability was 0%.

UNTREATED BEST CASE (UTBC) SCENARIO COMMENTS

There is a paucity of data regarding the duration of healing for an untreated shoulder dislocation. No articles regarding this scenario could be found. In the best-case scenario, the shoulder is easily reducible, so it is possible that spontaneous reduction could occur in the absence of treatment. The best-case treated duration was used as an approximation given the limited data available. The RTDC probability for a best-case scenario shoulder dislocation was pre-determined by the Clinical & Science Team to be 0%. Based on review articles identified in the worst-case treated scenario (Zacchilli and Owens, 2010; Simonet et al, 1984; and Hovelius, 1982), LOCL was assumed to be 0%. No literature search was performed for LOCL for this scenario.

UNTREATED WORST CASE (UTWC) SCENARIO COMMENTS

The duration for the worst-case untreated scenario has been assumed to be the same as the best-case scenario. Goga, 2003 presents chronic shoulder dislocations from a hospital in South Africa (32 patients, 19M, 13F, average age 45.5 years, range of 15-83 years). Once care was initiated for these patients with dislocations, treatment and duration of therapy was similar to the worst-case treated scenario. The RTDC values for the treated worst-case scenario were used for the untreated scenario. Based on review articles identified in the worst-case treated scenario (Zacchilli and Owens, 2010; Simonet et al, 1984; and Hovelius, 1982), LOCL was assumed to be 0%. No literature search was performed for LOCL for this scenario.

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

Citation	Source	LOC Value
Watson et al, 2016	Terrestrial	1
Kirkley et al, 2005	Terrestrial	
Bottoni et al, 2002	Terrestrial	
Goga, 2003	Terrestrial	

Watson et al, 2016 was used for durations for treated best-case, but it is a poor representation of our population given: the mean age of participants was 16.5 years, and it focused on return to play protocols for sporting activities. Similarly, Kirkley et al, 2005 was a Canadian study of 40 male, skeletally mature subjects, under age 30, comparing immobilization treatment to arthroscopic stabilization for 5 years of follow-up. Bottoni et al, 2002 followed a group of 24 military patients at Tripler Army Hospital in Hawaii. 14 were treated non-operatively for acute, traumatic, first-time shoulder dislocation and the remaining 10 were treated operatively with a Bankart repair. They were followed for an average of 36 months. Patients ranged from age 18-26. These age ranges are all lower than the astronaut population and the treatment approach for patients under 30 is more aggressive (surgical intervention is favored due to risk of recurrent dislocation from instability. There is a paucity of data regarding untreated shoulder dislocations. Goga, 2003 presents chronic shoulder dislocations (for worst-case untreated scenario) from a hospital in South Africa (32 patients, 19M, 13F, average age 45.5 years, range of 15-83 years) and provides similar durations to the treated worst-case scenario.

TABLE 6. RTDC LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Stayner et al, 2000	Terrestrial	2
Visser et al, 1999	Terrestrial	
Cutts et al, 2009	Terrestrial	

CST consensus determined that in a best-case scenario the RTDC probability would be 0%. For the untreated scenario the search yielded multiple articles, but based on the CST assumption of 0% it appears they were disregarded. For the worst-case scenarios, Cutts et al, 2009 is a review article that presents a lower limit of nerve injury as 10% for the axillary nerve. Stayner et al, 2000 was a review article for shoulder dislocations in patients over the age of 40 (presenting risk of vascular injury of 1-2%) and Visser et al, 1999 reviewed risk of nerve injury as a result of anterior shoulder dislocation and had an average age of the population of 52.3 years. They noted 48% of patients sustained axonal loss nerve injuries, but at 12-45 weeks the majority had healed. These are more appropriate age ranges to apply to the astronaut population than those used for the duration values.

TABLE 7. LOCL LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Zacchilli and Owens, 2010	Terrestrial	3
Simonet et al, 1984	Terrestrial	
Hovelius, 1982	Terrestrial	

In the best-case treated scenario, literature searches revealed review articles that support a 0% probability of LOCL. It was assumed based on these sources that LOCL probability would be 0% for all remaining scenarios and no further literature searches were performed.

CAPABILITY RESOURCE TABLE (CRT) OVERVIEW

Overview The condition Dislocation – Shoulder includes both anterior and posterior dislocation of the glenohumeral joint. Note, this does not include fractures secondary to dislocation. CNES: N/A Diagnostic Scope and Resourcing In the best-case scenario the diagnosis is based on history, physical examination (musculoskeletal and neurologic), and imaging. Plain film (X-Ray), CT, and MRI will be unavailable inflight. Musculoskeletal ultrasound was included in the CRT as it may serve as a useful adjunct in diagnosis for some cases, but it was not considered a necessary capability to diagnose a dislocated shoulder. In the worst-case scenario, vital signs are also included in the physical examination. This diagnostic framework is consistent with the terrestrial workup for shoulder dislocation 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): 1.37 hours CP1 WC (Treated or Untreated: 1.45 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 Terrestrial management of shoulder dislocation includes reduction, followed by a period of immobilization and physical therapy. The best-case scenario involves an easily reducible dislocation, whereas the worst-case scenario involves the possibility of a difficult, or even impossible reduction. Thus, procedural sedation and a glenohumeral injection were included in the worst-case scenario only. A swing and swath capability was included for immobilization. Physical therapy was included. Exercise modification is also recommended, but not built into the CRT as this does not represent a clinical resource. Pain is variable. NSAIDs and acetaminophen were included in the best-case scenario. The worst-case scenario additionally includes a glenohumeral local anesthetic and a short course of narcotics. A short course of narcotics was added in the worst-case scenario. Communications and Support Needs While real-time video and audio loop communications are desired for diagnosis and treatment, they were not considered a necessity, 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

The IMM CLiFF best- and worst-case definitions are based on radiographic (MRI) findings in a dislocated shoulder. Since MRI will not be available inflight, the Clinical & Science Team altered the best- and worst-case definitions to be more clinically focused. Therefore, there is no comment about labral tears in the current definition as this would not be possible to definitively diagnose in-flight. RTDC values in this CLiFF are notably lower than IMM (Evac was 100% for every scenario except best-case treated in IMM). LOCL is 0% for all scenarios in this CLiFF, as it was in IMM. Task impairment values are similar to the functional impairment values from IMM.

LIMITATIONS SUMMARY

• Much of the data used to inform this CLiFF is based on articles with populations under the age of 20 years old (particularly duration data). The management of first-time shoulder dislocations is very different depending on age. Those under age ~30 have a much higher risk of recurrent dislocation due to instability. Thus, surgical management is typically indicated in this young population. Those over age 30 (like our astronaut crewmember population) are not at as high of a risk for recurrence due to instability, so first-line treatment is reduction followed by immobilization (not surgery). The data for this CLiFF would be more appropriate to our population if it focused only on shoulder dislocations in those over age ~30. • RTDC was assumed to be 0% by CST for best-case scenarios. Despite this, a search was performed for the untreated best-case scenario that yielded multiple results, but they were disregarded based on the CST assumption. • All LOCL values for scenarios other than best-case treated scenario are based on the best-case treated scenario search results. No LOCL searches were run for the other scenarios.

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)		664										
Untreated Best Case (UTBC)		664					145					
Treated Worst Case (TWC)		664										
Untreated Worst Case (UTWC)	223	664		89	854	44	145					
	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	1455	3763	0.38666	38.666
Untreated Best Case (UTBC)	132		414				34	211	1600	3763	0.425193	42.5193
Treated Worst Case (TWC)	132		414				34	211	1455	3763	0.38666	38.666
Untreated Worst Case (UTWC)	132	564	414				34	211	3374	3763	0.896625	89.6625

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)	132		414				34	211	791	3763	0.210205	21.0205
Treated Worst Case (TWC)									0	3763	0	0
Untreated Worst Case (UTWC)	132		414				34	211	791	3763	0.210205	21.0205

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.

REFERENCES

Reference

1. Brewster SJ. Preventing Injuries in the U.S. Military: The Process, Priorities, and Epidemiologic Evidence. 2008.

2. Bottoni CR, Wilckens JH, DeBerardino TM, D'Alleyrand JC, Rooney RC, Harpstrite JK, et al. A prospective, randomized evaluation of arthroscopic stabilization versus nonoperative treatment in patients with acute, traumatic, first-time shoulder dislocations. Am J Sports Med. 2002;30(4):576-80. Epub 2002/07/20. doi: 10.1177/03635465020300041801. PubMed PMID: 12130413.

3. Cutts S, Prempeh M, Drew S. Anterior shoulder dislocation. Ann R Coll Surg Engl. 2009;91(1):2-7. Epub 2009/01/08. doi: 10.1308/003588409x359123. PubMed PMID: 19126329; PubMed Central PMCID: PMCPMC2752231.

4. Goga I. Chronic shoulder dislocations. Journal of shoulder and elbow surgery. 2003;12(5):446-50.

5. Health H. Shoulder Dislocation Harvard Health; [cited 2021 4/28]. Available from: https://www.health.harvard.edu/a_to_z/shoulder-dislocation-a-to-z.

6. Hovelius L, Olofsson A, Sandström B, Augustini B, Krantz L, Fredin H, et al. Nonoperative Treatment of Primary Anterior Shoulder Dislocation in Patients Forty Years of Age and Younger: A Prospective Twenty-five-Year Follow-up. J Bone Joint Surg Am. 2008;90:945-52.

7. Kirkley A, Werstine R, Ratjek A, Griffin S. Prospective randomized clinical trial comparing the effectiveness of immediate arthroscopic stabilization versus immobilization and rehabilitation in first traumatic anterior dislocations of the shoulder: long-term evaluation. Arthroscopy. 2005;21(1):55-63. Epub 2005/01/15. doi: 10.1016/j.arthro.2004.09.018. PubMed PMID: 15650667.

8. Owens BD, Dawson L, Burks R, Cameron KL. Incidence of shoulder dislocation in the United States military: demographic considerations from a high-risk population. J Bone Joint Surg Am. 2009;91(4):791-6. Epub 2009/04/03. doi: 10.2106/JBJS.H.00514. PubMed PMID: 19339562.

9. Paterson WH, Throckmorton TW, Koester M, Azar FM, Kuhn JE. Position and duration of immobilization after primary anterior shoulder dislocation: a systematic review and meta-analysis of the literature. J Bone Joint Surg Am. 2010;92(18):2924-33. Epub 2010/12/17. doi: 10.2106/jbjs.J.00631. PubMed PMID: 21159993.

10. Simonet WT, Melton LJ, 3rd, Cofield RH, Ilstrup DM. Incidence of anterior shoulder dislocation in Olmsted County, Minnesota. Clin Orthop Relat Res. 1984(186):186-91. Epub 1984/06/01. PubMed PMID: 6723141.

11. Stayner LR, Cummings J, Andersen J, Jobe CM. Shoulder dislocations in patients older than 40 years of age. Orthop Clin North Am. 2000;31(2):231-9. Epub 2000/03/29. doi: 10.1016/s0030-5898(05)70143-7. PubMed PMID: 10736392.

12. Visser CP, Coene LN, Brand R, Tavy DL. The incidence of nerve injury in anterior dislocation of the shoulder and its influence on functional recovery. A prospective clinical and EMG study. J Bone Joint Surg Br. 1999;81(4):679-85. Epub 1999/08/27. doi: 10.1302/0301-620x.81b4.9005. PubMed PMID: 10463745.

13. Watson S, Allen B, Grant JA. A Clinical Review of Return-to-Play Considerations After Anterior Shoulder Dislocation. Sports Health. 2016;8(4):336-41. Epub 2016/06/02. doi: 10.1177/1941738116651956. PubMed PMID: 27255423.

14. Zacchilli MA, Owens BD. Epidemiology of shoulder dislocations presenting to emergency departments in the United States. J Bone Joint Surg Am. 2010;92(3):542-9. Epub 2010/03/03. doi: 10.2106/jbjs.I.00450. PubMed PMID: 20194311.

15.Goldstein L, Ghobrial M. Dislocated Shoulder: Approaches to lessen the pain of reduction techniques. Pract Pain Manage. 2011. 11:6. Retrieved from https://www.practicalpainmanagement.com/pain/other/dislocated-shoulder-approaches-lessen-pain-reduction-techniques.

16. Hasebroock AW, Brinkman J, Foster L, Bowens JP. Management of primary anterior shoulder dislocations: a narrative review. Sports Medicine - Open 2019; 5:31.

17. Verweij LP, Baden DN, van der Zande JM, van den Bekerom MP. Assessment and management of shoulder dislocation. BMJ 2020; :m4485.

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