Clinical Finding Form (CliFF)

Branch	Baseline

ICL28_Dental Abscess

There are multiple types of isolated dental abscesses. Gingival abscesses occur between the gums and the teeth. Periodontal abscesses occur in diseased gums in periodontal pockets, between the gum and the tooth, below the enamel of the tooth. Periapical and apical abscesses occur at or near the tip of the root of the tooth. These are typically the most severe. Finally, pericoronal abscesses occur around impacted or partially erupted teeth. (Vilardi, 2017; Nguyen and Martin, 2008; Herrera et al, 2000; Hodapp and Jeske, 2020). The acute apical/periapical dental abscess typically arises secondary to dental caries, trauma, or failed root treatment. After the intact pulp chamber is breached, colonization of the root canals occurs with a diverse mix of anaerobic bacteria (Robertson and Smith, 2009). While asymptomatic necrosis is common, abscess formation occurs when these bacteria and their toxic products enter the periapical tissues via the apical foramen and induce acute inflammation and pus formation (Nair, 2004). The main signs and symptoms of the acute apical/periapical dental abscess are pain, swelling, erythema and suppuration usually localized to the affected tooth. The abscess can frequently spread causing a spreading odontogenic infection which can be accompanied by sepsis syndrome (Robertson, 2009). Note that Sepsis is a separate CLiFF and will not be addressed as a sequela of dental abscess in this CLiFF. Terrestrially, the vast majority of dental abscesses respond to surgical treatment, such as drainage of pus and elimination of the source of infection, with antibiotic use limited to severe spreading infections. A dental emergency has not occurred among US astronauts in flight (Hodapp and Jeske, 2020).

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 is no published account of in-flight dental abscess in spaceflight. However, two articles presented the incidence of dental abscess in US astronaut crewmembers. Menon, 2012 performed a retrospective review of dental incidents in crewmembers including the following sources/timing: PubMed (inflight dental incidents), LSAH database (pre-flight and inflight), and flight surgeon recollection for undocumented events (unspecified timing). It revealed the following pre-flight incidence: In male crewmembers there were a total of 5 carries (0.00006%), 4 abscesses (0.00005%), and 11 periodontal disease cases (0.00013%) in 173,450 person-days. In female crewmembers there were 0 caries, and 0 abscesses, and 1 case of periodontal disease in 43,855 person-days. Menon voices concerns that this is an under-representation of dental events by stating, "This data was likely an under-representation of actual disease since not all data were recorded and captured by this query. In fact, personal communication from local flight surgeons (handwritten dental reports, debrief notes, electronic medical records, and private medical conference notes) confirmed that LSAH data only captured a small subset of dental complaints." Brown et al, 1974 is a small (n = 18) but astronaut specific population that followed the Skylab prime and back-up crewmembers over a 9 month pre-flight period and found an incidence of 1 abscess during this timeframe.

ANALOG LITERATURE

Christine et al, 1995 presents 18 Everest mountaineers, 2 of which had a dental abscess on a 1992 expedition. Deutsch, 2008 studied the incidence of various dental emergencies among US Navy submarine personnel, from 1997 to 2000. Smoking was significantly associated with the occurrence of a periodontal-related emergency and also with the occurrence of any dental emergency. There are a greater percentage of smokers among submariners than the astronaut corps. This study is also limited in that it applies only to adult men, 88.5 percent Caucasian, and 70.5 percent were 25 years old or older. There were 21 dentist visits due to periapical abscess (using the surrogate ICD-9-CM code 522 "pulp and periapical") over 5946.9 person-years yielding an incidence rate of 0.0035 events per person-year.

TERRESTRIAL LITERATURE

Gray et al, 1994 presents a review of 5467 army clinic record visits. 203 patients had periodontitis, and periodontal abscesses were diagnosed in 56 patients (1%). This is at a deployed dental clinic in Rota, Spain and included active duty service members and their dependents. The mean age of the population was 37 years. 72% of the population was male. Lewis et al, 1989 performed a retrospective questionnaire of 340 general practices in the UK seeing 121,900 patients over a one-month time period and found 14-25 cases of acute dento-alveolar abscess per 1000 patients. There is no demographic information available for the patient population of this study.

OVERALL INCIDENCE SUMMARY

INCIDENCE

Mean: 0.006718
SD: 0.003371

INCIDENCE SUMMARY

The incidence for this condition is informed by a retrospective review by Menon, 2012 and based on pre-flight astronaut data (astronaut selection to first flight). There were 4 total abscesses over 594.9787 person-years. IR 6.723E-3 (95%CI: 2.136E-3, 16.22E-3). The posterior distribution for the incidence rate under an uninformative prior is Gamma(shape=3.9716, rate=591.184) with mean 0.006718 and SD 0.003371.

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
0.00671804
SD
0.00337101

Gamma
(Shape): 3.9716
(Rate): 591.184

TABLE 2. INCIDENCE LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Menon,2012	Spaceflight Extravehicular	4
Deutsch, 2008	Analog	3
Christine et al, 1995	Analog	1
Brown et al, 1974	Spaceflight	3
Gray et al, 1994	Terrestrial	3
Lewis et al, 1989	Terrestrial	1

Menon, 2012 is a surveillance report from a PubMed search, LSAH data specific to astronauts, and a query of flight-surgeons for recollection of undocumented reports of dental incidents. Deutsch, 2008 is a large analog data set of US Navy submariners, stratified by characteristics that may apply to astronauts. Notably, it does not include any females. Christine, 1995 is a very small analog data set (n=18) during an Everest expedition. It presents a high incidence and it is unclear how pre-existing dental hygiene played a role. Brown et al, 1974 is another very small (n = 18) but astronaut specific population that followed the Skylab back-up crewmembers over a 9 month period. Gray et al, 1994 is a large terrestrial data set of primarily healthy adults with an average age similar to astronauts, but dental clinic visits raise pre-test probability of dental problem. Lewis et al, 1989 is a terrestrial data set from UK, with an unknown age range of the participants and a high likelihood of dental visits for existing problems.

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

Crewmembers undergo dental screening examinations at the time of selection and comprehensive annual dental examinations and cleanings. At 6 months before launch crewmembers additionally undergo a complete dental examination. If treatment is deemed necessary, all such treatment is completed 3 months before launch. All astronauts are expected to maintain optimal physical and oral health and to follow oral hygiene practices (Hodapp and Jeske, 2020).

BEST CASE SCENARIO DEFINITION

An abscess that responds to treatment with pain medication and antibiotics.

WORSE CASE SCENARIO DEFINITION

An abscess that does not respond to oral treatment or topical anesthetic and requires IV antibiotic administration and/or incision/drainage. (The development of sepsis secondary to necrosis is addressed in the condition Sepsis).

CONDITIONS INCLUDED, BUT NOT EXPLICITLY STATED (CNES)

None

BEST CASE/WORST CASE PROBABILITY COMMENTS

Boykin et al, 2003 performed a prospective study of 873 individuals of the age 45 years or older, who had telephones, were not living in an institutional setting, had at least one tooth, and lived in one of four Northern Florida counties. The average age of participants was not listed. They note that 11% of those who had a dental abscess during the 48 month follow-up period did not seek dental care. Of those who sought dental care, 71% with dental abscess had either an extraction or root canal. This value is being used for the worst-case probability. The primary limitation of this study is the lack of demographic information for the patient population. This is likely an over-representation of the worst-case scenario as compared to the astronaut corps (who have very good dentition based on screening at selection). This is a limitation of the data. Note that IMM used this same reference to inform worst-case probability. However, IMM assigned a worst-case probability of 0-42% based on 42% of patients requiring extraction only. An additional 12% of patients had at least one extraction AND one root canal. An additional 17% had root canal only. Cumulatively, this represents a 71% worst-case scenario. (Both root canal and extraction are definitive care for a periapical/apical abscess). For this reason, this effort will use 71% for the worst-case probability.

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

Citation	Source	LOC Value
Richardson, 2005	Terrestrial	0
Boykin et al, 2003	Terrestrial	2
Adriaenssen, 1998	Terrestrial	0

Richardson, 2005 is a retrospective analysis of UK armed forces in Iraq during Operation Telic from January 2003- May 2003. They present data regarding the number of periapical abscesses and periodontal abscesses. There are qualifiers for periapical abscesses of "no root canal therapy" and "failing root canal therapy." It is not stated within the article whether this is referring to the treatment rendered after the discovery of the abscess or prior, thus this article is not useful for best and worst-case probability. Boykin et al, 2003 performed a prospective study of 873 individuals of the age 45 years or older, who had telephones, were not living in an institutional setting, had at least one tooth, and lived in one of four Northern Florida counties. The average age of participants was not listed. They note that 11% of those who had a dental abscess during the 48 month follow-up period did not seek dental care. Of those who sought dental care, 71% with dental abscess had either an extraction or root canal. This value is being used for the worst-case probability. Adriaenssen et al, 2003 is a randomized trial of azithromycin vs. co-amoxiclav for the treatment of acute periapical abscesses from 106 dental clinics in Belgium. 19% of these patients failed oral antibiotic treatment, but this isn't a true best-case/worst case probability split in this study because they excluded anyone requiring incision and/or drainage. If they had provided the initial study population and then listed who was excluded and why, a true worst-case probability could be derived, but this information is lacking. This paper does not inform the best- and worst-case probability decision.

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: 0.006718 SD: 0.003371	29 - 29	100	0.93	7.36115	72	168	5.60723	0	0	0	0
Treated Worst Case (TWC)		71 - 71	100	1.43	18.177	72	211.2	5.60723	0	26	0.1	0.48
Untreated Best Case (UTBC)	N/A	N/A	N/A	0.93	42.9445	72	168	42.9445	0	26	0.1	0.48
Untreated Worst Case (UTWC)	N/A	N/A	N/A	1.43	42.9445	72	504	42.9445	0	100	10	40

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

A dental abscess in spaceflight (particularly a peri-apical/apical abscess) is a serious condition that could cause sudden incapacitation of a crewmember (Hodapp and Jeske, 2020). Terrestrially, the standard of care is early incision and drainage without antibiotics. However, the best- and worst-case definitions for this condition deviate from terrestrial care due to spaceflight considerations. Per Hodapp and Jeske (2020), a crewmember with an apical abscess should immediately be started on antibiotics and, if the infection can be controlled inflight, receive a root canal post-flight. If the infection cannot be controlled inflight with antibiotics, dental extraction is advised for an apical abscess (Hodapp and Jeske, 2020). Note, the worst-case scenario does not comment on dental extraction, but it is resourced in the CRT for this condition. The RTDC surrogates used for this CLiFF were "hospitalization" and "deep space infection." See comments pertaining to individual scenarios below.

TREATED BEST CASE (TBC) SCENARIO COMMENTS

The treated best-case duration of 72-16 hours (3-7 days) was informed from Oberoi et al, 2015 which states that most odontogenic infections resolve, with antibiotic treatment, in this timeframe. Based on the best-case scenario definition of responsiveness to treatment, the assumption was made that both RTDC and LOCL probabilities would be 0%. No RTDC or LOCL literature searches were performed.

TREATED WORST CASE SCENARIO (TWC) COMMENTS

The treated worst-case scenario duration is based on Mair et al, 2020 (an analysis of pediatric and adult surgically drained dental infections); Matijevic et al, 2009 (assessing the efficacy of empiric antibiotics in addition to surgical drainage); and Al-Nawas et al, 2009 (a prospective randomized trial of moxifloxacin efficacy after incision and drainage). The shortest duration after incision and drainage was identified as 64.8 hours, which is shorter than the best-case treated duration. This is not unexpected given the definitions of best-case (antibiotic treatment only) and worst-case (incision and drainage). It would be anticipated that an abscess would heal faster after incision and drainage. To minimize confusion, the minimum duration for both treated best-case and worst-case was set at 72 hours. A dental abscess that has spread to a deep space infection of the head/neck or requires hospitalization were used as the RTDC surrogates for this scenario. Akinbami et al, 2010 performed a retrospective study of odontogenic infections that presented to the hospital. None of the patients with localized infection (that had not spread to surrounding tissues) were hospitalized. Thus, the minimum probability for RTDC was chosen as 0%. The maximum probability of RTDC of 26% is informed from Alotaibi et al, 2015, a retrospective analysis of hospitalized odontogenic infections assessing their risk to spread. 26% of dental abscesses spread to surrounding tissues in this study. In a large retrospective analysis of patients hospitalized for dental abscess, Shah et al (2013) report a mortality rate of 0.1%. This study included 61,439 US participants with an average age of 37 years old (51.1% female, 61.3% Caucasian, 83.6% of hospitalizations were in urban areas). This was selected as the minimum probability for LOCL for a treated, worst-case dental abscess. Similarly, Rampa et al, 2019 found a mortality rate of 0.48% following hospitalization for dental abscess based on a retrospective review utilizing data from the Nationwide Emergency Department Sample (USA) 2014-2018. This was selected as the maximum probability for LOCL for the treated, worst-case dental abscess.

UNTREATED BEST CASE (UTBC) SCENARIO COMMENTS

There is a paucity of data for untreated dental abscesses. (Terrestrial standard of care advocates not to treat with antibiotics, rather to treat only with early I&D, but this does not constitute a lack of treatment since I&D is definitive treatment in many cases). No data was identified in the literature search to inform untreated durations, or RTDC (LOCL search was not performed) but dental abscess literature does shows a strong consensus that an untreated dental abscess could progress to a more severe, or even deadly, infection. Therefore, the durations for the untreated best-case scenario will utilize the treated worst-case scenario values as a surrogate. (The treated best-case scenario is not an adequate surrogate in this situation given the literature consensus that lack of treatment can lead to severe outcomes. It would be an understimate of duration, RTDC, and LOCL. The treated worst-case scenario is felt to be a better surrogate). Note, duration, RTDC and LOCL may be underestimated in this scenario based on utilizing the treated worst-case scenario. This is a limitation due to the paucity of untreated data.

UNTREATED WORST CASE (UTWC) SCENARIO COMMENTS

There is again a paucity of data relating to mortality rates in truly untreated dental abscesses, because severe dental abscesses have not been left untreated since the pre-antibiotic era. Many modern papers cite Thomas (1908) who recorded mortality rates for severe infection before the possibility of treatment, and appears to be one of the few sources of this data. Three articles that are over 100 years old (pre-antibiotics) were identified to informed the duration for an untreated worst-case dental abscess. The aforementioned Thomas (1908) described the natural history of dental abscesses that have progressed to the severe complication of Ludwig's Angina. The described cases had a duration of 12 hours to 12 days and most cases resulted in death. Robinson (1909) is a case-study of an alveolar abscess that self-resolved after 3 weeks. Smith, 1897 provides a duration of 18 hours to 10 days. For consistency between the scenarios, the minimum duration was set at 72 hours. The maximum duration of 504 hours (3 weeks) was informed the maximum duration (Robinson, 1909). The paucity of current literature regarding untreated worst-case dental abscesses is a limitation of this CLiFF. RTDC probability was set at 0-100% based on the case report of a self-resolving worst-case dental abscess (Robinson, 1909) and reports of complications with high levels of morbidity (Thomas, 1908). LOCL probability was set at 10-40% based on Thomas (1908).

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

Citation	Source	LOC Value
Mair et al, 2020	Terrestrial	3
Matijevic et al, 2009	Terrestrial	
Al-Nawas et al, 2009	Terrestrial	
Thomas, 1908	Terrestrial	
Robinson, 1909	Terrestrial	
Smith, 1879	Terrestrial	
Oberoi et al, 2015	Terrestrial	

The durations for the treated scenarios are highly relevant to this CLiFF and the editor is confident in their values. The durations for the untreated scenarios are more nebulous given the paucity of data regarding lack of treatment for dental abscesses. The durations are based on literature that is over 100 years old and does constitute lack of treatment, but are descriptive reports and case studies.

TABLE 6. RTDC LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Alotaibi et al, 2015	Terrestrial	2
Akinbami et al, 2010	Terrestrial	
Ylijoki et al, 2001	Terrestrial	
Rampa et al, 2019	Terrestrial	
Thomas, 1908	Terrestrial	
Robinson, 1909	Terrestrial	
Smith, 1879	Terrestrial	

The treated best-case scenario was assumed to have an RTDC probability of 0% based on the definition of responsiveness to treatment. This is likely an accurate assumption, but was not verified with a literature search. The treated worst-case scenario RTDC probabilities are based on applicable terrestrial literature. There is an overall paucity of data regarding untreated scenarios. The best-case untreated scenario used the treated worst-case scenario RTDC probability as a surrogate. This may be an underestimate of the RTDC probability for this scenario. The worst-case untreated scenario RTDC is informed based on literature that is over 100 years old and comprised of descriptive and case reports.

TABLE 7. LOCL LEVEL OF CONFIDENCE (LOC)

Citation	Source	LOC Value
Shah et al, 2013	Terrestrial	3
Rampa et al, 2019	Terrestrial	
Thomas, 1908	Terrestrial	

The treated best-case scenario was assumed to have an LOCL probability of 0% based on the best case scenario definition. This is a reasonable assumption but was not substantiated with a literature search. The treated worst-case scenario LOCL probability was informed by data from strong retrospective analyses (Shah et al, 2013; Rampa et al, 2019) that provided mortality data from severe dental abscesses. There is a paucity of data for untreated scenarios. For the untreated best-case scenario, the treated worst-case scenario LOCL probabilities were used as a surrogate. For the untreated worst-case scenario LOCL, a single source of data (Thomas, 1908) was identified. It was a descriptive study of mortality due to dental abscess before antibiotics were available. This source was also used to inform duration and RTDC, but is most applicable to LOCL. In modern literature, it is frequently cited in dental journals as the anticipated probability of mortality from lack of treatment.

CAPABILITY RESOURCE TABLE (CRT) OVERVIEW

Overview

Dental abscess refers to any abscess associated with an infection of the gingival tissue surrounding the tooth. The best- and worst-case scenarios deviate from terrestrial standard of care. The best-case scenario indicates that the abscess responds to treatment with pain medications and antibiotics (no incision and drainage), whereas the worst-case scenario indicates that either IV antibiotics or I&D are required. Terrestrially, the standard of care is I&D first-line (without antibiotics) and IV antibiotics are not used for a localized dental abscess (IV antibiotics would be used if the infection was spreading to surrounding tissues of the head and neck only). For the purposes of this CRT, the terrestrial standards of care were followed as closely as possible.

CNES: None

Diagnostic Scope and Resourcing:

In the best-case scenario, diagnosis is based on history, and physical examination (dental, vital signs, oropharyngeal, neck, and focused skin exam of the area). Plain film (X-Ray), CT, and MRI will be unavailable inflight, but were felt to be unnecessary in the best-case scenario.

In the worst-case scenario, diagnostic capabilities are expanded to include ultrasound of the surrounding head/neck tissues to rule out spread of the infection beyond a localized tooth abscess.

Clinical Phase 1 Duration and Rationale

This version of IMPACT presumes physician level knowledge, skill, and ability will be present on the mission. This CRT includes a scope of practice code of 5 (which correlates to an “Experienced procedure trained generalist attending (ED attending).” The CRT working group SME consensus Clinical Phase 1 duration:

Best Case CP1: 0.93 hours
Worst Case CP1: 1.43 hours

Treatment Scope and Resourcing:

As stated in the overview, terrestrial standard of care indicates I&D as first line treatment without antibiotics. The best-case scenario includes pain management with NSAIDs/Acetaminophen, dental nerve block, and topical gingival treatments. Oral antibiotics are provided, per the definition but treating with antibiotics prior to I&D is a deviation from terrestrial standard of care. It is possible that in spaceflight a trial of antibiotics may be considered before I&D, however.

In addition to the above treatment modalities, the wort-case scenario includes incision and drainage and dental extraction capabilities. The CRT working group opted not to include IV antibiotics in the worst-case scenario because based on the literature they are outside the scope of an isolated dental abscess. IV antibiotics would be warranted in cases of spread of infection to the surrounding soft-tissues (cellulitis or other abscess) or sepsis. These constitute conditions outside 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, 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

The best-case scenario definition is unchanged from IMM. The worst-case definition has changed slightly from requiring extraction to requiring IV antibiotics and/or incision/drainage. The incidence for IMM was based on a US Navy Submarine analog. It was noted in the IMM CLiFF that all the subjects were male and future incidence should include women, which this CLiFF had done by utilizing Menon, 2012 to inform the distribution. Updated data for incidence, duration, RTDC, and LOCL is being used to inform these parameters in IMPACT 1.0. The worst-case probability for this effort is informed from the same reference that IMM used. However, IMM assigned a worst-case probability of 0-42% based on 42% of patients requiring extraction only. An additional 12% of patients had at least one extraction AND one root canal. An additional 17% had root canal only. Cumulatively, this represents a 71% worst-case scenario. (Both root canal and extraction are definitive care for a periapical/apical abscess). For this reason, this effort will use 71% for the worst-case probability.

LIMITATIONS SUMMARY

• Best-case/worst-case probability split is based off one study of a population that is likely poorly representative of the astronaut corps as it is suspected the population had much poorer dentition than astronauts as time of selection for a mission. (One of the inclusion criteria of the study was, “had at least one tooth”). Note, this is the same reference that IMM used previously. • For the best-case treated scenario RTDC and LOCL were both assumed to be 0% based on the BC definition. While this is likely an accurate assumption, it was not verified with a literature search. • For the untreated best-case scenario, there is a paucity of data regarding dental abscesses that go untreated: (Terrestrial standard of care advocates not to treat with antibiotics, rather to treat only with early I&D, but this does not constitute a lack of treatment since I&D is definitive treatment in many cases). No data was identified in the literature search to inform untreated durations, or RTDC (LOCL search was not performed) but dental abscess literature does shows a strong consensus that an untreated dental abscess could progress to a more severe, or even deadly, infection. Therefore, the durations for the untreated best-case scenario will utilize the treated worst-case scenario values as a surrogate. (The treated best-case scenario is not an adequate surrogate in this situation given the literature consensus that lack of treatment can lead to severe outcomes. It would be an underestimate of duration, RTDC, and LOCL. The treated worst-case scenario is felt to be a better surrogate). Note, duration, RTDC and LOCL may be underestimated in this scenario based on utilizing the treated worst-case scenario. This is a limitation due to the paucity of untreated data.

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)	223	664	113	89			145	5				
Treated Worst Case (TWC)		664					145	5				
Untreated Worst Case (UTWC)	223	664	113	89			145	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)	132							211	343	3763	0.0911507	9.11507
Untreated Best Case (UTBC)	132						34	211	1616	3763	0.429445	42.9445
Treated Worst Case (TWC)	132							211	1157	3763	0.307467	30.7467
Untreated Worst Case (UTWC)	132						34	211	1616	3763	0.429445	42.9445

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)	223	664	113	89			145	5				
Treated Worst Case (TWC)												
Untreated Worst Case (UTWC)	223	664	113	89			145	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)								211	211	3763	0.0560723	5.60723
Untreated Best Case (UTBC)	132						34	211	1616	3763	0.429445	42.9445
Treated Worst Case (TWC)								211	211	3763	0.0560723	5.60723
Untreated Worst Case (UTWC)	132						34	211	1616	3763	0.429445	42.9445

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