Eye Infection Cliff

Branch Baseline

Eye infection includes infections of the eyes and eye lids.

Chalazia and hordeola are sudden-onset localized swellings of the eyelid. A chalazion is caused by noninfectious meibomian gland occlusion, whereas a hordeolum is caused by infection. Both conditions initially cause eyelid hyperemia and edema, swelling, and pain. With time, a chalazion becomes a small nontender nodule in the eyelid center, whereas a hordeolum remains painful and localizes to an eyelid margin. Diagnosis is clinical. Treatment is with hot compresses. Both conditions improve spontaneously, but incision or, for chalazia, intralesional corticosteroids may be used to hasten resolution. (Merck Manual, 2007)

Conjunctivitis is an inflammation or microbial infection involving the mucous membrane of the surface of the eye. Conjunctival inflammation typically results from infection, allergy, or irritation. Symptoms are conjunctival hyperemia and ocular discharge and, depending on the etiology, discomfort and itching. Infectious conjunctivitis is most commonly viral or bacterial and is contagious. Rarely, mixed or unidentifiable pathogens are present. Numerous allergens can cause allergic conjunctivitis Nonallergic conjunctival irritation can result from foreign bodies; wind, dust, smoke, fumes, chemical vapors, and other types of air pollution; and intense ultraviolet light of electric arcs, sunlamps, and reflection from snow. Diagnosis of conjunctivitis and differentiation between bacterial, viral, and noninfectious conjunctivitis are usually clinical. (Merck Manual, 2008). Conjunctivitis is usually benign and self-limited. Statistics are scarce because most people do not seek for medical attention.

Herpes zoster ophthalmicus is reactivation of a varicella-zoster virus infection involving the eye. Symptoms and signs, which may be intense, include dermatomal forehead rash and painful inflammation of all the tissues of the anterior and, rarely, posterior structures of the eye. A complication of herpes zoster ophthalmicus is keratitis accompanied by uveitis may be severe and followed by scarring. (Merck Manual, 2008).

The cornea is subject to infection, noninfectious inflammation, ulceration, mechanical damage, and environmental injury. Infection (keratitis), frequently with secondary conjunctivitis, can be due to viruses, bacteria, Acanthamoeba, or fungi. Ulceration usually represents progression of keratitis. Symptoms that suggest corneal involvement rather than simple conjunctivitis include pain, particularly with exposure to light and slight impairment of vision. Bacterial keratitis is a sight-threatening process. It is rare in the United States (Merck Manual, 2008)

Incidence Data Included in the Model

The model imports the following incidence information from the IMM database: incidence data category, space adaption status, incidence data, 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. fixed data). Space adaptation identifies medical events that onset occurs in the first 5 days of flight and does not reoccur. Incidence values vary by data category and define the number of medical events per person-year or medical events per person-at-risk for each medical condition. Incidence values can be modified by crew characteristics such as gender. 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 crew member 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 IMM Technical Description Document.

Incidence	
Data Category:	In-flight
Space Adaptation:	No
Incidence Type:	Rate

Distribution Data	
Incidence:	Gamma
Occurrence:	Poisson

Data Characteristics	
Events:	12
Person Years:	45.49
Space Flight Incidence Rate (Events / Person Years):	12 / 45.49 = 0.263794240492416

Incidence Comments

Five cases have occurred in flight. (Walton, 2010)

All cases described have been eye lid infections: 3 styes, 1 blepharitis caused by hair, and eyelid pustules.

The incidence data was updated to integrate the Real World System observed events (3 ISS and 4 STS events) including 18.17 person years from our validation data set. This data set included the remaining Shuttle missions and ISS Expedition 31/32 through Expedition 39/40 (Saile, 2017).

Updated the Person-Years based on the revised real world system integrated incidence data. The integrated person years changed from 18.17 to 18.13 so the conditions person years changed from 45.53 to 45.49 (Saile L., 2017)

Information Regarding Prevention

Selection criteria

Disqualifying conditions in the eye category include: disease of either eye or supporting structure that may interfere with the performance of duties; any condition of the eyelids that impairs normal eyelid function; chronic blepharitis or blepharospasm; dacrocystitis; herpetic ulcer or history of herpetic ulcer; and inflammation of the uveal tract (iris, ciliary body, choroid) , acute, chronic or recurrent with the exception of uncomplicated post-traumatic iritis.

Conjunctivitis, chronic or recurrent, and chronic or recurrent keratitis require special consideration by the MSMB. (International Space Station Program, 2009)

Incidence Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
Walton, 2010	1	Incidence
Saile L., 2017	1	Incidence

Alternative Incidence Data

Analog populations

An analysis of 10 years of data collected on Polaris submarine patrols over the ten year period 1963-1973 reported a total of 1685 medical events treated. Illness rates are indicated as new/cases/1000 man-days. There were a total of 48 eye events. 23 eye cases during the 1963-67 period with an illness rate of 0.007; 77 sick days, and 1 EVAC; 25 cases during the 1968-73 period, with an illness rate of 0.006; 44 sick days and, 2 EVACS. There were 9 incidents of conjunctivitis, 3 keratoconjunctivitis, 2 iridocyclitis, and 1 uveitis. A total of 15 eye infections with 38 sick days from a total of 48 diseases of the eyes (Table A9). (Tansey, 1979) Eye events (n 48) accounted for 2.85% of the total medical events. Averaging the two period rates, we calculated an incidence of 0.0065 per 1000 man-days (0.0065*365 = 2.3725 / 1000 person years) or 0.0023725 person-years. Eye infections (15/48) accounted for 31.25% of total eye events, or a rate of 0.0000618. No information on which conditions required EVAC.

Thomas (Thomas, 2003) reported on health of US Navy submarine crews during periods of isolation. ICD-9 codes 360-379 (Eye and adnexa) occurred in 6 officers and 54 enlisted men. Total rate was 1.0 per 100 person years. Eye conditions included keratitis, disorders of the conjunctiva and inflammation of eyelids among officers. There is no similar information for enlisted men. Effect of illness was minimal 0.75 (officers) to 1 day (enlisted men). Only 4.2% officers and 7% of enlisted man had greater than 2 days illnesses. Thomas concluded that officers are most analogous to current space program participants. Majority of medical events reported were minor, non life-threatening, with little or no impact on unit mission.

Of the major diagnostic categories associated with medical communications, 5% were nervous and sense organs which include the eyes. Eye conditions were not among the leading diagnostic categories for MEDEVACs. (Nice, 1987)

Another report by Thomas, detailed 4.2% of procedures recorded during submarine patrols from January 1997 through December 1998 were Fluorescein staining of the eye. (Thomas, 2000)

A study of 107 ocular disease and nonbattle injuries (DNBI) seen at Walter Reed Army Medical Center between January 2003 and September 30 2005, with patients evacuated from Iraq and Afghanistan to the Ophthalmology Service and referred after being evacuated for treatment of other conditions. Ophthalmology typically accounts for 2.4 to 5.4% of all DNBIs and ranks in the top five or six disease categories. Eye findings ranged from minor to vision threatening. 84 soldiers (78.5% returned to duty). Hygiene, contact lens restriction and eye protection should be stressed to reduce ocular morbidity and need for evacuation. Infections seen were 5 infectious keratitis (3 bacterial) 4.7%, 1 viral conjunctivitis or 0.9%, 1 blepharitis or 0.9%, 14 uveitis or 13.1% (Psolka, 2007). Lack of information on the total population at risk during the mission time prevents us from calculating incidence rates from this study.

During Operation Telic, conflict period March 27 and May 1st 2003, 45 eye casualties presenting to a British Army Field Hospital accounted for 2% of all attendance (n 2292). Most common were eye injuries 58.7%. Conjunctivitis was the most frequent non-traumatic presentation, 22.22% (10/45). Other cases reported are 2 corneal abscesses, 2 sties, 1 iritis, 1 episcleritis, and 1 dacrocystitis. A total of 7 casualties required transfer to a UK facility (15.55%) 3 petrochemical injuries, 2 corneal abscesses, 1 corneal abrasion and 1 iritis. There is no report of the total population at risk during the mission time to calculate incidence rates. (Aslam, 2005) Of note, the total number of “other” cases is 7, or 15.55% (7/45) and 3 of them required evacuation.

Eye injury surveillance in the US Department of Defense (DoD) from medical visit data on active duty personnel, 1996 –2005, and causes of eye injury hospitalizations were obtained from the Defense Medical Surveillance System. Eye injury–related ICD-9-CM codes beyond the traditional 800–999 injury code set were included. Eye injury rates among active duty military personnel increased from 1996 to 2005 among both men and women (p less than 0.001), with the highest rates in 2004; 26/1000 person-years and 21/1000 person-years for women and men respectively. Women consistently had 7%–21% higher rates than men. From 2002–2005, rates were highest for those aged 40 years and older compared to those aged 17–19 years. Leading causes of eye injury hospitalizations were ordnance handling (16.9%), enemy action (13.1%), and fighting (11.9%). The term “eye” referred to hard and soft tissues of the orbital cavity and/or the adjacent and associated structures. Rates were calculated by dividing the number of injuries by the person-years of the DoD active duty population at risk, By age cohort 40 years and older 26 injuries/1000 person-years, or 0.026 person-years. Reported percentages and rates for conjunctivitis were (6.3%, 1.40/1000) and 3.5% for acute atopic conjunctivitis. (Hilber, 2010) We estimated conjunctivitis rate at 0.0014 per person-years and atopic conjunctivitis at 0.00091 (3.5% of 0.026)

Non Analog populations

The rate of emergency department–treated eye injury in the United States is 3.15 per 1000 population (95% confidence interval, 2.66-3.63). Rates were highest among those in their 20s and 30s, among males, and The most common injury to the eye was a contusion or abrasion (44.4%), followed by foreign bodies (30.8%), burns (10.2%), and conjunctivitis (9.9%) (Figure 3). These rates include only eyeball injuries and exclude adnexa. (McGwin, 2005). We calculated the conjunctivitis rate at 0.0002835 (9.9% of 0.00315).

Treatment and Outcomes

Based on the best evidence available best and worst case percentage ranges are assigned. The medical condition is divided into three clinical phases in all three clinical phases a functional impairment is assigned. The clinical phase I and II's functional impairments remain for the duration for that respective clinical phase. The function impairment in clinical phase III represents final impairment for this medical condition and remains for the rest of the mission. Other mission end states include evacuation and loss of crew life.

The IMM checks medical resource availability once the number of medical events and scenarios has been established. If there is not sufficient essential resources called out in the CliFF, then the medical condition will go down an untreated best or worst case scenario pathway.

The table below summarizes the treated and untreated best and worst case scenarios.

	Clinical Phase I Diagnosis & Initial Treatment[1]		**Clinical Phase II On-going Treatment / Convalescence[2]**		**Clinical Phase III Recovered / Mission End State[3]**		
	FI* (%)	**Duration (hrs)**	**FI* (%)**	**Duration (hrs) (Min - ML - Max)**	**FI* (%)**	**EVAC** (%)**	**LOCL** (%)**
ISS-based Treatment (best case scenario %: 84.62 - 92.31)	100	0.5 - 0.75	0 - 27	0 - 36 - 72	0	0	0
ISS-based Treatment (worst case scenario %: 7.69 - 15.38)	100	0.75	8 - 47	240 - 288 - 336	0 - 27	0 - 1	0
Untreated Best Case	0	0	8 - 47	0 - 36 - 72	0 - 27	0	0
Untreated Worst Case	0	0	28 - 60	240 - 288 - 336	8 - 60	0 - 100	0

[1]Clinical Phase I: Clinical phase I covers only the initial assessment of the affected crew member to define his or her medical condition, and completion of appropriate initial treatment to stabilize the crew member. While the affected crew member is being assessed, he or she is not able to perform any assigned tasks, thus Functional Impairment during this phase is considered 100%. In the untreated case, there is no diagnosis performed or treatment given, therefore Functional Impairment and Duration will always be "not applicable".

[2]Clinical Phase II: On-going Treatment and Convalescence- During clinical phase II, the affected crew member is receiving any appropriate follow-on treatment for his or her medical condition to allow the crew member to recover as much as he or she is able to recover in the ISS environment. Clinical phase II also encompasses relapses or reoccurrences of the same original medical condition in clinical phase I necessitating additional treatment or recovery time due to unsuccessful primary treatment response. The duration in Clinical Phase II is expressed in minimum, most likely (ML) and maximum hours. This was updated for future capabilities in IMM but is currently not being used by the model.

[3]Clinical Phase III: Recovered/Mission End State- Clinical phase III is reached once the affected crew member has recovered from the medical condition as much as he or she is able to recover in the ISS environment. This may or may not be recovery from the given medical condition to the full extent possible. If this "recovered" state results in an evacuation or loss of the crew member, this will be noted in the mission end state results.

*Functional Impairment (FI) is a measure of the affected crew member's health and performance ability.

**Two mission end state results are addressed in the CliFF: 1) Evacuation (EVAC) - crew and patient are evacuated from the spacecraft due to the medical condition, and 2) Loss of crew (LOCL) - death of affected crew member due to medical condition. EVAC is considered as an end state result if any of the following criteria are met: 1) potential LOCL, 2) potential significant permanent impairment, or 3) potential intractable pain. Probability distributions are assigned for each range of values within the Table of Treatments and Outcomes.

Refer to the Integrated Medical Model Technical Document for more information on how risk is reported by the IMM, Crew Health Index (CHI) and Quality Adjusted Mission Time calculations.

Definition and Probability of Best and Worst Case Scenario: (includes definitions of best and worst case scenarios and identifies the probability of those scenarios.)

Scenario Comments

Best case scenario is a mild eyelid infection or viral conjunctivitis.

Worst case scenario is defined as a moderate or severe eye infection which requires antibiotic or antiviral treatment.

Best and worst case scenarios percentages: based on Real World System data set, there were 7 events and 1 of them were worst case. Since we now have worst case scenarios, which did not have before, we can use the empirical data so the worst case scenario would be 14.29% (1/7). Thus the best case scenarios would be 85.71% (6/7) (Saile L., 2017).

Best Case Comments

Our functional impairments calculation for Eye Infection follows the IMM mild non-space adaptation template. Impairments of the Visual System and of the Whole Person are based on Table 12-10, p.307. Impairment for Visual System, class 3 is divided in 3a and 3b. We are arbitrarily assigning class 3a when using the mild non space adaptation template. (American Medical Association, 2008)

By definition in Clinical Phase I, FI is 100%. To follow procedures specified in ISS checklist, i.e. eye exam, for the best case scenario, duration is estimated at 30 to 45 minutes, 0.5 to 0.75 hours. During Clinical Phase II, FI is estimated at 0 to 27%. Duration is estimated in 0 to 72 hours. In Clinical Phase III, full recovery is expected and FI is 0%. Clinical practice experience suggests that the vast majority of conjunctivitis responds well without any treatment and very few patients with bacterial conjunctivitis require topical antibiotics (Barclay, 2010) (Abraham, 2006). By definition EVAC and LOCL would not be expected for the best case scenario.

Worst Case Comments

Our functional impairments calculation for Eye Infection follows the IMM mild non-space adaptation template. Impairments of the Visual System and of the Whole Person are based on Table 12-10, p.307. Impairment for Visual System, class 3 is divided in 3a and 3b. We are arbitrarily assigning class 3a when using the mild non space adaptation template. (American Medical Association, 2008)

By definition in Clinical Phase I, FI is 100%. Duration to follow procedures specified in ISS checklist, i.e. eye exam, and applying topical medications for the worst case scenario, is estimated in 45 minutes, or 0.75 hours. During Clinical Phase II, FI is estimated in 8 to 47%. Duration is estimated at 240 to 336 hours or 10 to 14 days. In Clinical Phase III, full recovery may or may not occur and FI is 0-27%. EVAC has occurred in analog populations. (Aslam, 2005) Clinical practice experience suggests that the vast majority of conjunctivitis responds well without any treatment and very few patients with bacterial conjuntivitis require topical antibiotics (Barclay, 2010) (Abraham, 2006). In our population we would expect the risk of EVAC to be very low. Therefore, we estimated EVAC is to be 0-1%. LOCL is not expected for eye infection.

Untreated Best Case Comments

Our functional impairments calculation for Eye Infection follows the IMM mild non-space adaptation template. Impairments of the Visual System and of the Whole Person are based on Table 12-10, p.307. Impairment for Visual System, class 3 is divided in 3a and 3b. We are arbitrarily assigning class 3a when using the mild non space adaptation template. (American Medical Association, 2008)

During Clinical Phase II, FI is estimated in 8 to 47%. Duration is 0 to 72 hours, similar to the treated best case scenario. In Clinical Phase III, recovery may or may not occur and FI is estimated at 0-27%. By definition EVAC and LOCL would not be expected for the best case scenario.

Untreated Worst Case Comments

Our functional impairments calculation for Eye Infection follows the IMM mild non-space adaptation template. Impairments of the Visual System and of the Whole Person are based on Table 12-10, p.307. Impairment for Visual System, class 3 is divided in 3a and 3b. We are arbitrarily assigning class 3a when using the mild non space adaptation template. (American Medical Association, 2008)

During Clinical Phase II, FI is estimated in 28 to 60%. Duration is estimated at 240 to 336 hours or 10 to 14 days, similar to the treated worst case scenario. In Clinical Phase III, recovery is unlikely and FI is estimated at 8 to 60%. Even minor injuries may incapacitate personnel and if untreated cause severe visual loss. Therefore the worst case estimate for EVAC is 0-100% to account for uncertainty. (Aslam, 2005) LOCL is not expected for eye infection.

Treatment and Options Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
American Medical Association, 2008	3	FI
Aslam, 2005	2	EVAC
Barclay, 2010	4	EVAC
Abraham, 2006	4	EVAC
Saile L., 2017	1	BCWC

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Cotton swabs	0	6	6	Yes	No	to apply medications
Cyclopentolate 1% 15mL bottle	0.004	0.06	1	Yes	Yes	Pupil dilation
Fluorescein 1mg strips (2 strips)	1	1	10	Yes	Yes	fluorescent chemical used to examine the cornea.
Gauze pads (4x4)	1	1	50	Yes	No	to absorb medications & tears
Moxifloxacin (Avelox) 0.5%, 3ml bottle	0	0.28	4	Yes	Yes	Treat infections
Otoscope (Head, Handle, and USB cable)	1	1	1	No	Yes	Light source for eye exam
Penlight	1	1	2	No	Yes	Eye exam
Penlight Blue Filter	1	1	2	No	Yes	Eye exam
Proparacaine eye drops 0.5%, 15mL bottle	0.013	0.013	1	No	No	eye anesthetic
Refresh artificial tears (Carboxymethylcellulose) 0.5%, 0.4mL bottle	1	1	40	Yes	Yes	to rinse eye

Resource Comments

Eye infection is included in the ISS medical checklist (Mission Operations Directorate (MOD), 2011). We updated the resources table and included resources for eye exam, i.e. Otoscope handle, Ophthalmoscope Head, Cotton Swabs, Gauze Pads, Proparacaine Eye Drops, Artificial Tears, Magnifying Glass, Visual Acuity Card, and Cyclogyl ophthalmic solution.

Comparison with terrestrial guidelines

Terrestrial guidelines for conjunctivitis recommend removing contact lenses, and treatment with topical non-steroidal anti-inflammatory drugs non-steroidal or non-prescription analgesics to relieve discomfort until symptoms resolve within 48–72 hours. (ECRI Institute, 2011)

Required Resources Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
NASA Mission Operations Directorate (MOD), 2011	2	Resources

Level Of Evidence

Input Data	LOE Average
Incidence	1
Functional Impairment	3
Best Case / Worst Case	1
EVAC / LOCL	3.33333333333333
Resources	2
QUALITY OF EVIDENCE	**2.06666666666667**

Description	Range
Excellent	1-2
Good	2.1-3
Fair	3.1-4
Poor	4.1-5

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