Eye Irritation/Abrasion Cliff

Branch Baseline

Corneal abrasions are usually self-limited, superficial corneal defects. Foreign bodies in the eye are a common cause of corneal abrasions. Corneal abrasions from blunt trauma are also very common. Diagnosis is with fluorescein staining and examination under a blue light. In corneal abrasion the stroma is clear; a white infiltrate may indicate bacterial or fungal keratitis. Superficial foreign bodies are usually removed under topical anesthesia, at slit lamp, with a hypodermic needle. Occasionally a rust ring forms around a foreign body and can also be removed. Conjunctival foreign bodes are usually removed by saline irrigation or occasionally with forceps. A note should be made of any foreign body composition and type as well as any significant past ocular history that might be important in ophthalmic management and the prognosis. (Blanch, 2009)

The risk of injury from a foreign body is higher in microgravity because particulates float freely in the cabin and follow prevailing air currents. (Manuel, 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:	106
Person Years:	45.49
Space Flight Incidence Rate (Events / Person Years):	106 / 45.49 = 2.33018245768301

Incidence Comments

Foreign bodies and eye abrasions have occurred in space flight (Walton, 2010). Foreign bodies accounted for 88.5% (62/70) and abrasions for 11.5% (8/70) of the events.

The most frequently described foreign bodies are particulates (16), particles (9), debris (5) or lint (4) in the air (34/62). They range from minor events relieved by blinking to moderate events causing irritation for hours and up to 1 day. We have no information on the treatment received for this type of injury.

There were 8 abrasion events caused by more potentially damaging foreign bodies i.e. velcro, piece of metal (3), fiberglass, and drink bag. One abrasion did not have the etiology documented. We have no details on the treatment or recovery time for these events. One eyelid laceration caused iridocyclitis and visual acuity decrement, lasted 13 days and was treated on board with topical antibiotics and steroids. Recovery was complete.

Increased total medical events by 26 and added 18.17 person years based on the data from the Real World System (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)

The 10 events removed from *Eye Chemical Burn* are now added to *Eye Irritation/Abrasion* STS events after independent review of all of these iMED changes by Dr. Rahul Suresh, NASA flight surgeon with operational experience.

New incidence for *Eye Irritation/Abrasion* is (from 96 events per 45.49 person years = 2.11035) 106 events per 45.49 person years = 2.33018.

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. (International Space Station Program, 2009)

Contingency measures

Foreign bodies may be removable by eye wash.

Other

Neither the space Shuttle nor the International Space station provide the capability for repairing complex wounds such as eyelid or lacrimal sac lacerations. (Marshburn, 2008)

Portable ultrasound devices have been tested terrestrially in a gelatinous ocular model for use on board. They may be used to detect foreign objects of varying location, size (0.5-2 mm), and material (glass, plastic, metal). It can be used by operators with varying training to detect the presence, location, and composition of intraocular foreign bodies with high sensitivity, specificity, and accuracy. (Sargsyan, 2008)

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 11 foreign body incidents and 1 corneal abrasion 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. Foreign body/abrasion (12/48) accounted for 25% of total eye events, or a rate of 0.000593125. Foreign body caused 14 sick days, or an average of 1.27 (14/11) sick days per person while corneal abrasion required 2 sick days. 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. Some eye injury codes may have been included under the injury category, such as 870 laceration, open wound of eye and adnexa, or 918 eye abrasion but it is not possible to segregate this information further. 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. Conditions seen include: 3 Corneal scars (2.8%), 1 corneal abrasion (0.9%), and 1 foreign body (0.9%) (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%, and conjunctivitis was the most frequent non traumatic presentation. Foreign body presented 7 events and corneal abrasion 16. 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. One EVAC due to abrasion accounts for 14% of total EVACS (1/7) and 4.3% for this condition (1/23). There is no report of the total population at risk during mission time to calculate incidence rates. (Aslam, 2005)

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 the age of cohort 40 years and older yielding 26 injuries/1000 person-years, or 0.026 person-years. Reported percentages and rates for corneal abrasions and lacerations accounted for 26.7% of all patient visits for eye injuries, with an incidence rate of 5.89 per 1000 personnel. Foreign body external eye accounted for 3.6% and corneal foreign body accounted for 4.9%. (Hilber, 2010) We estimated foreign body percentage at 8.5% (3.6+4.9%) and incidence rate at 0.00221 (8.5% of 0.026) per person-years. Rate of corneal abrasion and lacerations is 0.00589 per person-years (5.89 per 1000 personnel).

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. 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 a total percentage of eye abrasion/foreign body (44.4+ 30.8%) 75.2. 75.2 % of 0.00315 to be 0.00234248 incidence rate. The rate for contusion/abrasion is 0.0013986 (44.4 % of 0.00315) and for foreign body 0.0009702 (30.8 % of 0.00315) This may be an over estimation because there is no segregation by contusions versus abrasions.

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 %: 99.06 - 100)	100	0.5 - 0.75	0 - 27	24 - 36 - 48	0	0	0
ISS-based Treatment (worst case scenario %: 0 - 0.94)	100	0.75 - 1.5	8 - 47	48 - 192 - 336	0 - 27	0 - 1	0
Untreated Best Case	0	0	8 - 47	24 - 36 - 48	0 - 27	0	0
Untreated Worst Case	0	0	28 - 60	48 - 192 - 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 defined as dry, irritated eyes or a corneal abrasion/foreign body that spontaneously resolves or can be easily treated, and does not affect vision.

Worst case scenario is defined as a corneal abrasion/foreign body that requires treatment, and affects vision or has the potential to result in a permanent impairment of vision.

Percentages of how often best versus worst case scenarios occur were estimated using in-flight data (Walton, 2010)All in-flight cases to date have been best case scenarios. If the next case were to be a best case scenario, then the percentage of best case scenarios would be 100% (71/71) and the percentage of worst case scenarios would be 0% (0/71). If the next case were to be a worst case scenario, then the percentage of best case scenarios would be 99% (70/71) and the percentage of worst case scenarios would be 1% (1/71). To allow for uncertainty, it is estimated that 99-100% of cases will be best case scenarios and 0 to 1% of cases will be worst case scenarios.

The Real World System data integrated with the previous in-flight data set calculates to the same percentages for best and worst case scenarios. There were no worst case so if the next case were to be a worst case scenario the percentage would be 1% (1/97). While if the case was a best case the precentage would be 100% (97/97). Therefore the worst case percentage is 0-1% and the best case percentage is 99-100% (Saile L., 2017)

April of 2020 - With the addition of 10 events (that were removed from Eye Chemical Burn and added to this condition) from the RWS data, and using the algorithm described above, if the next case was worst case we would have 0.94% (1/106) and if the next case was best case we would have 100% (106/106). Thus, worst case percentage is 0 - 0.94% and best case is 99.06 - 100%.

Best Case Comments

Our functional impairments calculation for Eye Abrasion 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 24 to 48 hours based in Thomas study (Thomas, 2003). In Clinical Phase III, full recovery is expected and FI is 0%. Based on in-flight data, no EVAC has occurred, making our EVAC rate 0%. By definition LOCL would not be expected for the best case scenario.

Worst Case Comments

Our functional impairments calculation for Eye Abrasion 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, removal of foreign body, and applying topical medications for the worst case scenario, is estimated in 45 to 90 minutes, or 0.75 to 1.5 hours. During Clinical Phase II, FI is estimated in 8 to 47%. Duration is estimated at 48 to 336 hours or 2 to 14 days base on in-flight data durations (In-flight Compilation Lockdown revised, 2010). In Clinical Phase III, full recovery may or may not occur and FI is 0-27%. EVAC has occurred in analog populations. (Aslam, 2005)at a rate of 4%. However, eye abrasion has not caused any EVACs among astronauts' crew, and our EVAC rate is 0%. Based on in-flight data (n 70), if the next case requires EVAC, it would be 1.4% (1/71) (In-flight Compilation Lockdown revised, 2010) . To allow for uncertainty we are estimating the risk of evacuation as 0-1%. LOCL is not expected for eye abrasion.

Untreated Best Case Comments

Our functional impairments calculation for Eye Abrasion 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 24 to 48 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 Abrasion 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 48 to 336 hours or 2 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. (Aslam, 2005) Because of potential significant permanent impairment EVAC is estimated at 0-100%. LOCL is not expected for eye abrasion.

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
Walton, 2010	1	BCWC
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	2	2	6	Yes	No	to apply topical medication and/or remove foreign body
Cyclopentolate 1% 15mL bottle	0.039	0.08	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)	2	2	50	Yes	No	to absorb blood or fluids from skin
Medical tape	0	0.03	5	Yes	No	single-coated pressure adhesive tape, to apply eye pad
Moxifloxacin (Avelox) 0.5%, 3ml bottle	0.04	0.04	4	Yes	Yes	Treat infection
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	0.03	1	No	No	eye anesthetic
Refresh artificial tears (Carboxymethylcellulose) 0.5%, 0.4mL bottle	1	1	40	Yes	Yes	relief dryness/irritation of the eyes, to flush eye
Tylenol (Acetaminophen) 325 mg	2	10	150	Yes	Yes	pain relief

Resource Comments

Foreign body abrasion is included in the ISS medical checklist (International Space Station Integrated Medical Group, 2008). All resources in the table are available on board.

We updated the table to add towel and deleted Ciloxan ointment.

Comparison of ISS procedures with terrestrial guidelines: The ISS procedures are similar to terrestrial military guidelines (Blanch, 2009)topical anesthetic, eye examination, clinically and by fluorescein stain, prophylactic antibiotics, removal of foreign body by flushing the eye, eye patch if necessary. Dissimilarities refer to lack of imaging equipment on board and foreign body mechanical removal with cotton swab versus removal with hypodermic needle terrestrially.

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
International Space Station Integrated Medical Group, 2008	2	Resources

Level Of Evidence

Input Data	LOE Average
Incidence	1
Functional Impairment	3
Best Case / Worst Case	1
EVAC / LOCL	2
Resources	2
QUALITY OF EVIDENCE	**1.8**

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

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