Indigestion Cliff

Branch Baseline

Indigestion is also known as dyspepsia. Dyspepsia refers to group of upper gastrointestinal symptoms that occur commonly in adults. Dyspepsia is known to result from organic causes, but the majority of patients suffer from non-ulcer or functional dyspepsia. (Mahadeva, 2006)

Dyspepsia is a complex of symptoms referable to the upper GI tract. There are different definitions of dyspepsia in common usage. A broad definition, which includes any symptom thought to be referable to the upper GI tract, was proposed by some. The Rome criteria were first described and published in 1991, and restrict the definition of dyspepsia to a feeling of pain or discomfort centered in the upper abdomen. These were revised on two subsequent occasions. The latest revision, Rome 3, divides functional dyspepsia into two separate syndromes: postprandial distress and epigastric pain. The Rome criteria are preferred in the United States. Individuals with reflux symptoms are considered to have gastroesophageal reflux disease. (Ford, 2009)

Gastroesophageal reflux disease (GERD) may be defined as chronic symptoms or mucosal damage produced by the abnormal reflux of gastric contents into the esophagus. The most commonly recognized manifestation of GERD is heartburn or a substernal burning sensation in the chest. (Shaheen, 2002)

Since the discovery of the causative role played by H. pylori in the pathogenesis of both gastric and duodenal ulcer peptic ulcer disease is declining, as well as their complications such as perforation and hemorrhage. Uninvestigated dyspepsia is the term used for individuals presenting with symptoms for the first time. (Ford, 2009)

Some mechanisms for the increased risk of indigestion on orbit. This includes a recent episode of nausea and vomiting associated with space motion sickness which could result in a mild gastritis/esophagitis. Abdominal organs shift cephalad in microgravity, changing the pressures experienced at the gastro-esophageal sphinctor. Due to the loss of some sense of taste from head congestion, there is often an increase in the ingestion of spicy foods. (Marshburn, 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:	11
Person Years:	45.49
Space Flight Incidence Rate (Events / Person Years):	11 / 45.49 = 0.241811387118048

Incidence Comments

Six events of indigestion have occurred in space flight (STS). Four have been described as indigestion, one as esophagitis and heartburn or reflux, and one as reflux. Three of them occurred in early flight. The other 3 on flight day 5 or after. (Walton, 2010)

There were 29 events described as flatulence or bloating which are not included as incidence data. (Walton, 2010)

Integrated the real world system incidence data added (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 abdomen/digestive system area include: chronic diseases or disorders of the alimentary tract that interfere with performance of duties, significant diseases of the esophagus such as strictures and Barrett's esophagus, chronic gastritis or chronic abdominal pain, history of mild reflux symptoms requires special consideration by the MSMB; previous endoscopic diagnosis of ulcers of the stomach or duodenum (other than medication induced or from infection with H. pylori). Medication or H. pylori induced ulcers must be endoscopically cleared as resolved; chronic dependence on acid reduction medication; history of gastrointestinal bleeding from any cause except for post-traumatic bleeding, medication induced gastritis, or minor bleeding (such as hemorrhoids or resolved infectious colitis). In the general category: In general, any medical condition that, in the judgment of the MSMB, may compromise mission operations, performance of duties, or crew health or safety. (International Space Station Program, 2009)

Other

Upper gastrointestinal problems have not significantly affected space flight operations to date, but mild complaints suggestive of gastritis and gastroesophageal reflux are commonly reported by crewmembers. These symptoms are generally self-limited and are usually relieved by over the counter Simethicone and antacids. (Marshburn, 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 229 gastrointestinal diseases during the 1963-73 period with an illness rate of 0.05 and 0.03; for the 1963-67 and 1968-73 periods respectively. There were 17 gastritis events; causing 24 sick days, 1.4 days per event. 4 Gastroduodenitis events, with 10 sick days during the 1963-1973 period, 1 event of duodenal ulcer requiring surgery caused 12 sick days, 1 perforated ulcer, sick days not reported. (Tansey, 1979)

Incidence rates 0.05 and 0.03 per 1000 man-days (0.05 and 0.03 * 365/ 1000) equal 0.01825 and 0.01095 person-years, for the periods 1963-1967 and 1968-1973, respectively. The average of these two incidence rates is 0.0146 per person-years. Gastritis and gastroduodenitis (21/229) accounted for 9.6% of total gastrointestinal events, or a rate of 0.001752. Six EVACs occurred but there is no information by condition. The two ulcers in the surgery group (2/269) are 0.7 % of the surgeries.

Thomas reported on health of US Navy submarine crews during periods of isolation. ICD9 code 520-579 The incidence rate for Digestive System Disorders was 2.0 for officers and 3.6 for enlisted crew, per 100 person years. Effect of illness was minimal 0.75 (officers) to 1 day (enlisted men). Digestive was the second most common cause of limited or no duty. 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. (Thomas, 2003) The incidence rate per person-years is 0.02 (2.0/100) and 0.036 (3.6/100). We cannot segregate the data for diseases of esophagus, stomach, and duodenum, ICD9 codes 530–537. Evacuations are not included in the study report.

A descriptive analysis was undertaken to evaluate for Disease and Non-Battle Injuries (DNBI) casualty care statistics incurred by a U.S. Army Brigade Combat Team (BCT) during a counterinsurgency campaign of Operation Iraqi Freedom. Of the 4,122 soldiers deployed, there were 1,324 DNBI with 5 (0.38%) deaths, 208 (15.7%) medical evacuations (MEDEVAC), and 1,111 (83.9%) returned to duty. The DNBI casualty rate for the BCT was 257.0/1,000 soldier combat-years. Females, compared with males, had a significantly increased incidence rate ratio for becoming a DNBI casualty 1.67 (95% CI 1.37, 2.04). Of 47 female soldiers receiving MEDEVAC 35 (74%) were for pregnancy-related issues. Musculoskeletal injuries (50.4%) and psychiatric disorders (23.3%) were the most common body systems involved with DNBI casualties. Gastrointestinal diseases accounted for 4.7% of total events (63/1324). MEDEVAC occurred to 27.0%; 73%, returned to duty and none died. (Belmont, 2010) No details of which conditions were included in the analysis and which have a MEDEVAC outcome.

The United States Air Force (USAF) waiver file and the Office of Medical Support database were used to identify 100 pilots with onset of duodenal ulcer (DU) between 1981 and 1987 to study course and prognosis of this disease in pilots. A written questionnaire was returned by 86 (86%) of these pilots. The incidence of DU in USAF active-duty pilots was estimated to be 5.0 per 10,000 pilot-years. DU was significantly associated with cigarette smoking. Bleeding ulcers were significantly associated with aspirin use. After 587 person-years of follow-up there were no fatalities; serious sequelae were reported in only 6 pilots, and moderate sequelae in only 12 others. The risk of recurrence of DU in this population was not appreciably higher among those initially presenting with hemorrhage. Surgery was the initial intervention for 5% of subjects. There were 14 pilots who reported in-flight symptoms, 3 had initially presented with bleeding and 11 without bleeding. Only one pilot considered symptoms severe enough to interfere with flying duties. By age, 30-39, 40-49, and 50 and older cohorts rates were 4.4, 5.4 and 8.2 respectively. All per 10,000 pilot-years. (Lyons, 1990) Rates per year are 0.00044, 0.00054, and 0.00082.

Non Analog Populations

The National Institutes of Health reports incidence and prevalence of Digestive Diseases in the United States. Gastroesophageal Reflux Disease (GERD) was by far the most frequently first-listed digestive system condition at ambulatory care visits, constituting 17.5 percent of all digestive system diagnoses. All rates are per 100,000. Ambulatory care visits, first listed diagnosis rates age cohorts 15-44 and 45-64 are 1,656 and 3,484 respectively. Hospital discharge rates, first listed diagnosis are 22 and 75 for the same age cohorts. Mortality rates are 0.0 and 0.2 (Everhart, 2011) Rates per person year are 0.01356 and 0.03484

Peptic ulcer disease. Peptic ulcers are coded by anatomical location (stomach, duodenum, gastrojejunum, and unspecified), chronicity, and by complication (hemorrhage or perforation). The frequency of outpatient and inpatient care has declined for peptic ulcer disease. All rates are per 100,000. Ambulatory care visits, first listed diagnosis rates, age cohorts 15-44 and 45-64 are 199 and 233 respectively. Hospital discharge rates, first listed diagnosis are 19 and 75, for the same age cohorts. Mortality rates are 0.1and 0.9 (Everhart, 2008) Rates per person year are 0.00199 and 0.00233.

The incidence rates for this condition were calculated by adding GERD and peptic ulcer disease. Rates per person year for the age cohort 15-44 are 0.01555 and for the age cohort 45-64 are 0.03717.

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 %: 83.33 - 91.67)	100	0.25	0 - 17	0 - 12 - 24	0	0	0
ISS-based Treatment (worst case scenario %: 8.33 - 16.67)	100	0.5	2 - 40	72 - 156 - 240	0 - 17	0 - 1	0
Untreated Best Case	0	0	2 - 40	0 - 12 - 24	0 - 17	0	0
Untreated Worst Case	0	0	25 - 66	72 - 156 - 240	2 - 66	0 - 3	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: Defined as mild indigestion, most likely due to gastro-esophageal reflux (GERD), esophagitis, or gastritis that resolves with minimal or no treatment.

Worst case scenario: Defined as moderate or severe indigestion, including duodenal and/or gastric ulceration, and either requiring prolonged treatment, or leading to complications such as gastrointestinal bleeding.

Best and worst case scenario percentages: based on Real World System data set, there were 5 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 20% (1/5). Thus the best case scenarios would be 80% (4/5) (Saile L., 2017).

Best Case Comments

Indigestion's functional impairments (FI) calculation follows the IMM mild non-space adaptation template. Upper Digestive Tract ratings are based on Table 6-4, p-107. (American Medical Association, 2008) Bleeding Disorders ratings are based on Table 9-11, p-205 (American Medical Association, 2008). Total FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008).

By definition in Clinical Phase I, FI is 100%. Duration of physical exam as described in ISS checklist for the best case scenario is estimated to be 15 minutes. During Clinical Phase II, FI is estimated in 0 to 17%. Duration is estimated to be 0 to 24 hours. In Clinical Phase III, full recovery is expected and FI is 0%. By definition EVAC and LOCL are not expected for the best case scenario.

Worst Case Comments

Indigestion's functional impairments (FI) calculation follows the IMM mild non-space adaptation template. Upper Digestive Tract ratings are based on Table 6-4, p-107. (American Medical Association, 2008) Bleeding Disorders ratings are based on Table 9-11, p-205 (American Medical Association, 2008). Total FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008).

By definition in Clinical Phase I, FI is 100%. Duration of physical exam as described in ISS checklist is estimated to be 30 minutes. During Clinical Phase II, FI is estimated in 2 to 40%. Duration is estimated to be 72 to 240 hours, 3 to 10 days. In Clinical Phase III, full recovery may or may not occur and FI is estimated at 0-17%. Active duodenal ulcer requiring hospitalization has occurred in the astronaut corps on the ground. Class IIC is expected to be manageable with HMS, but may necessitate emergent evacuation if condition does not improve or worsens (Johnston, 2008). To allow for uncertainty EVAC is estimated at 0-1%. By definition, LOCL is not expected for this condition.

Untreated Best Case Comments

Indigestion's functional impairments (FI) calculation follows the IMM mild non-space adaptation template. Upper Digestive Tract ratings are based on Table 6-4, p-107. (American Medical Association, 2008) Bleeding Disorders ratings are based on Table 9-11, p-205 (American Medical Association, 2008). Total FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008).

During Clinical Phase II, FI is estimated at 2 to 40%. Duration is expected to be 0 to 24 hours, similar to the treated best case scenario. In Clinical Phase III, recovery may or may not occur without treatment. FI is estimated at 0-17%. By definition, EVAC and LOCL are not expected for this condition.

Untreated Worst Case Comments

Indigestion's functional impairments (FI) calculation follows the IMM mild non-space adaptation template. Upper Digestive Tract ratings are based on Table 6-4, p-107. (American Medical Association, 2008) Bleeding Disorders ratings are based on Table 9-11, p-205 (American Medical Association, 2008). Total FI ratings are calculated combining the mentioned tables using the Combined Values Chart as indicated in Appendix A, pp 604-606 (American Medical Association, 2008).

During Clinical Phase II, FI is estimated at 25 to 66%. Duration is estimated to be 72 to 240 hours, 3 to 10 days, similar to the treated worst case scenario. In Clinical Phase III, recovery is unlikely and FI is estimated at 2-66%. A bleeding ulcer without available treatment may require EVAC. Based on data for complications in the management of peptic ulcer disease with bleeding we estimate EVAC to be at 0-3%. (Ford, 2009), (Chey, 2007) LOCL is not expected for this scenario.

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
American Medical Association, 2008	3	FI
American Medical Association, 2008	3	FI
Johnston, 2008	2	EVAC
Ford, 2009	4	EVAC
Chey, 2007	4	EVAC
Saile L., 2017	1	BCWC

Additional Comments

Irritable bowel syndrome, commonly included in the medical literature with functional disorders, is not included in this condition.

Cholecystitis, which may present with some similar symptoms, is addressed in the Acute Cholecystitis CliFF.

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
BZK wipes	0	1	60	Yes	No	Cleanse skin.
ECG Monitor (Device, USB Charge Cable, Lead Set Cable, Cue Card)	0	1	1	No	Yes	Measure and monitor ECG
Pack of 12 ECG electrodes	0	1	5	Yes	Yes	Measure and monitor ECG
Pepto-Bismol 262mg chewable tabs	2	0	80	Yes	Yes	to relieve abdominal cramping
Phenergan (Promethazine tablet) 25 mg	0	6	100	Yes	Yes	anti nausea
Prilosec 20mg	0	90	90	Yes	Yes	Control gastric acid

Resource Comments

The table was revised on 9/2/2011. Resources for nasogastric suctioning, i.e. medical tape, nasogastric tube, suction curette tip, suction device, suction collection bag, and suction device syringe were added, as well as antibiotics for peptic ulcer treatment.

The ISS medical checklist includes procedures for Stomach Upset – Indigestion. Abdominal pain includes treatment for nausea/vomiting, gas and diarrhea. Nasogastric tube insertion is listed as a separate procedure for bloody vomit or diarrhea (MOD, 2011). Treatments from the three mentioned tables were combined. Antibiotics were added as recommended by current Clinical guidelines (Ford, 2009); (Chey, 2007). All resources are available on board.

Comparison of ISS Medical checklist versus clinical guidelines

The ISS medical checklist recommends treating GERD symptoms similar to clinical guidelines. (Armstrong, 2005); (Ford, 2009). It also recommends treatment for nausea and gastric suctioning as necessary.

Testing for H. pylori and endoscopy are not available on board.

Treatment for hypovolemic shock secondary to bleeding is addressed in the Hypovolemic Shock Clinical Findings Form.

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
Chey, 2007	3	Resources
Ford, 2009	3	Resources

Level Of Evidence

Input Data	LOE Average
Incidence	1
Functional Impairment	3
Best Case / Worst Case	1
EVAC / LOCL	3.33333333333333
Resources	2.66666666666667
QUALITY OF EVIDENCE	**2.2**

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

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