



# Quantitative Validation of the IMM for ISS Missions

Millennia Young<sup>1</sup>

J. Arellano<sup>2</sup>, L. Boley<sup>1</sup>, Y. Garcia<sup>1</sup>, L. Saile<sup>1</sup>, M. Walton<sup>1</sup>, E. Kerstman<sup>3</sup>, D. Reyes<sup>3</sup>, D. A. Goodenow<sup>4</sup>, and J. G. Myers<sup>4</sup>

<sup>1</sup>Wyle

<sup>2</sup>MEIT

<sup>3</sup>UTMB

<sup>4</sup>NASA GRC.

Observed: LSAH data on 32 ISS person-missions including all inflight medical events

Predicted: 31 IMM runs

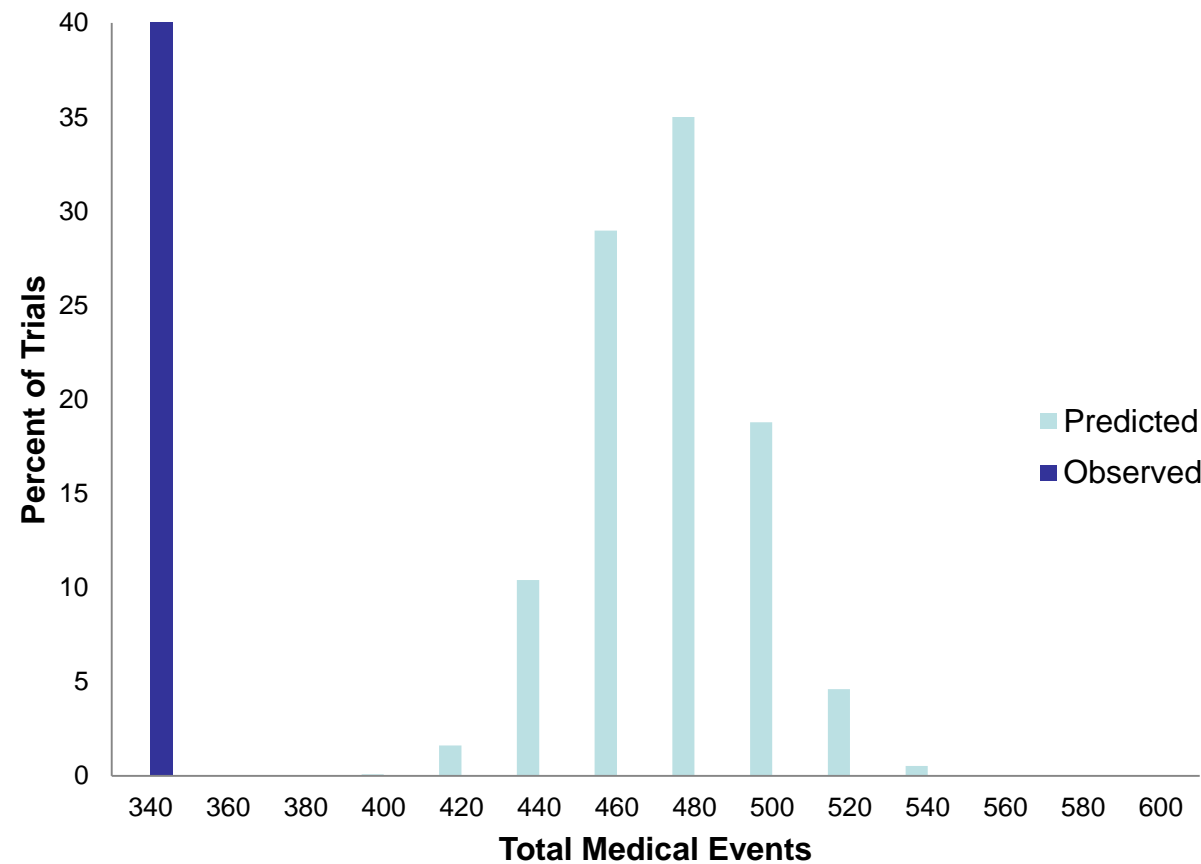
- IMM Inputs corresponding to the observed mission characteristics:
  - Mission Length
  - Number of crew
  - Crew Characteristics
- IMM Outputs for comparisons:
  - Total Number of Medical Events (TME)
  - EVAC/LOCL
  - Number of each medical condition

Parameter	Visualization	Comparison	Performance Characterization
TME	Scatter plot of observed vs predicted (by mission and by condition separately)	Regression with intercept. Intercept should be 0 and slope should be 1.	Determine if these values (0, and 1) fall within 90% CIs of the estimates
		Regression without intercept (fixed at 0). Coefficient of determination ( $R^2$ ) will serve as a metric of agreement. It is bounded on [0, 1] with 0 reflecting no agreement and 1 reflecting perfect agreement.	$R^2$ estimate should be significantly increased from 0. Resulting p-value (testing difference from 0) should be less than 0.1.
	Histogram of predicted TME across ISS program with the observed events marked	Observed number of events should be within the simulation distribution	Observed value should be within the 90% simulation intervals of the prediction
EVAC/ LOCL	Histograms of total simulated EVAC/LOCLs across ISS program	Results should not be inconsistent with zero EVAC/ LOCL	Observed value (0) should be within the 90% simulation intervals of the prediction
	Whisker chart of predicted probabilities of EVAC/LOCL		
Medical Condition-Specific Counts	Histogram of predicted counts across set of missions with the observed events marked	Observed number of events should be within the simulation distribution	Observed value should be within the 90% simulation intervals of the prediction

# Total Medical Events

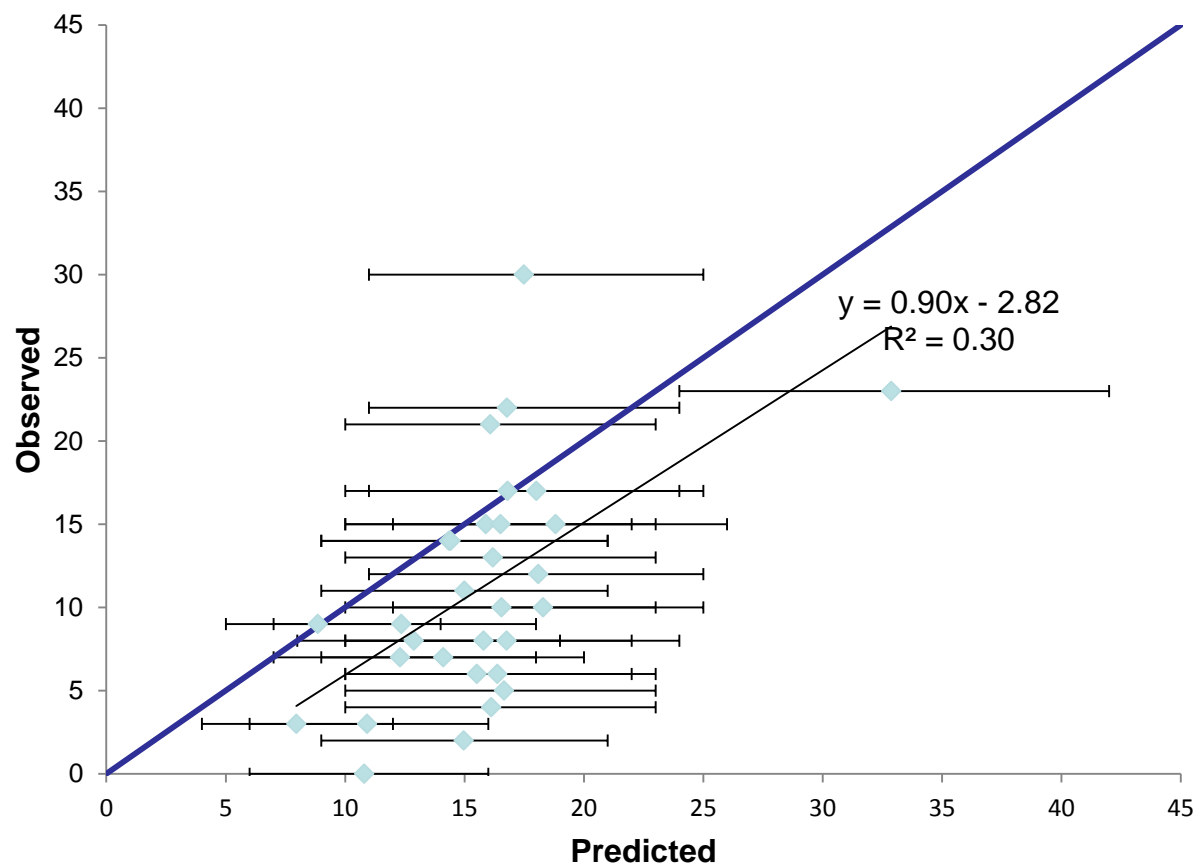


Over the entire set of missions



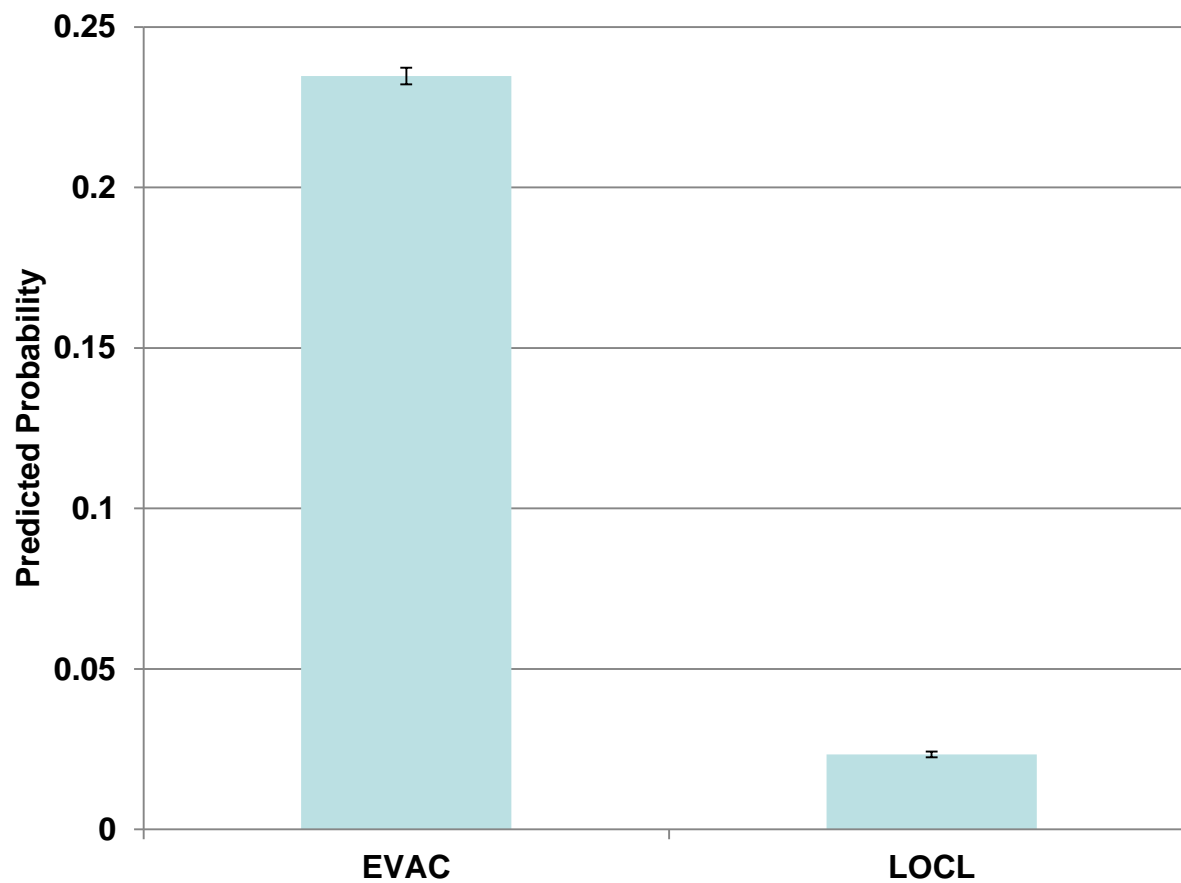
	Observed	Predicted	90% Confidence Interval
TME	344	508	(472, 554)

# Total Medical Events



Regression	Estimate	90% Confidence Interval
Intercept	-2.82	(-9.74, 4.10)
Slope	0.90	(0.47, 1.33)

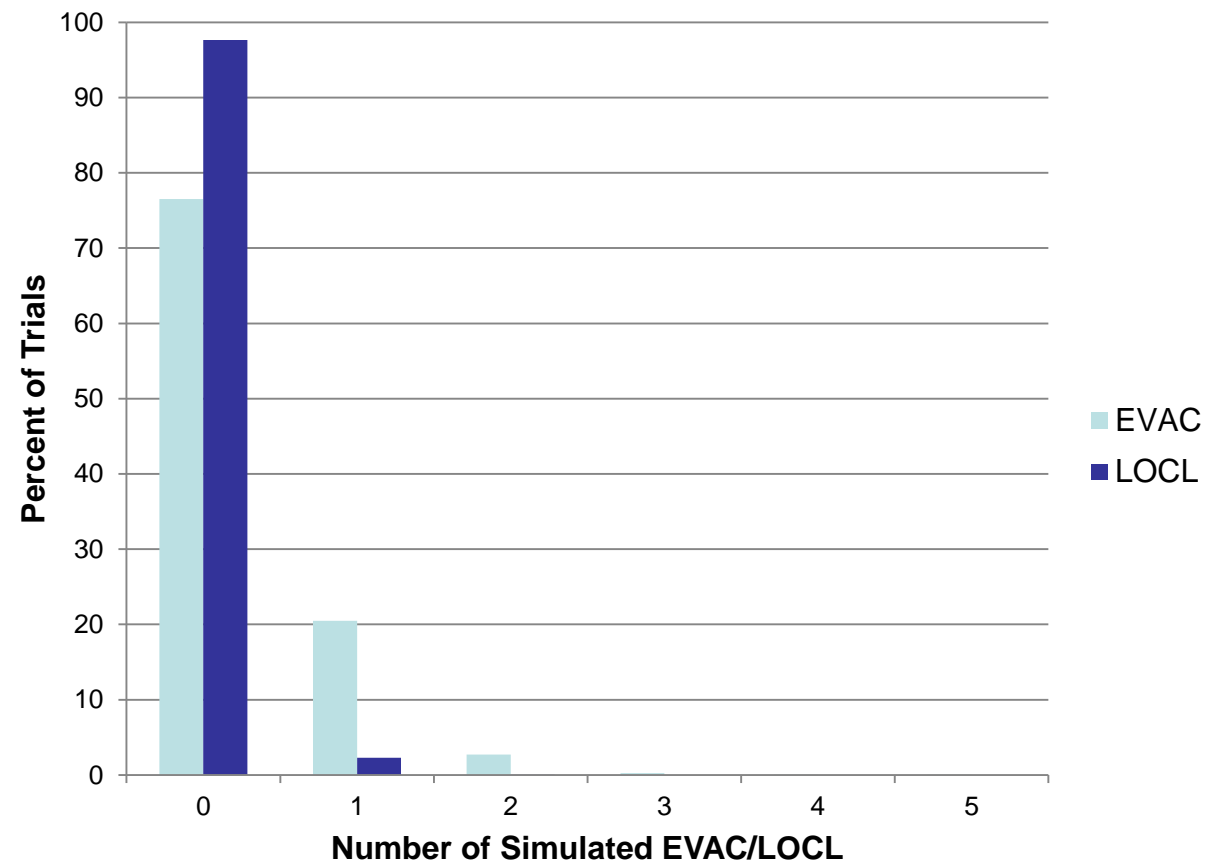
# EVAC/LOCL - Probability



	Probability	90% Confidence Interval
EVAC	0.2347	(0.2321, 0.2373)
LOCL	0.0234	(0.0225, 0.0243)

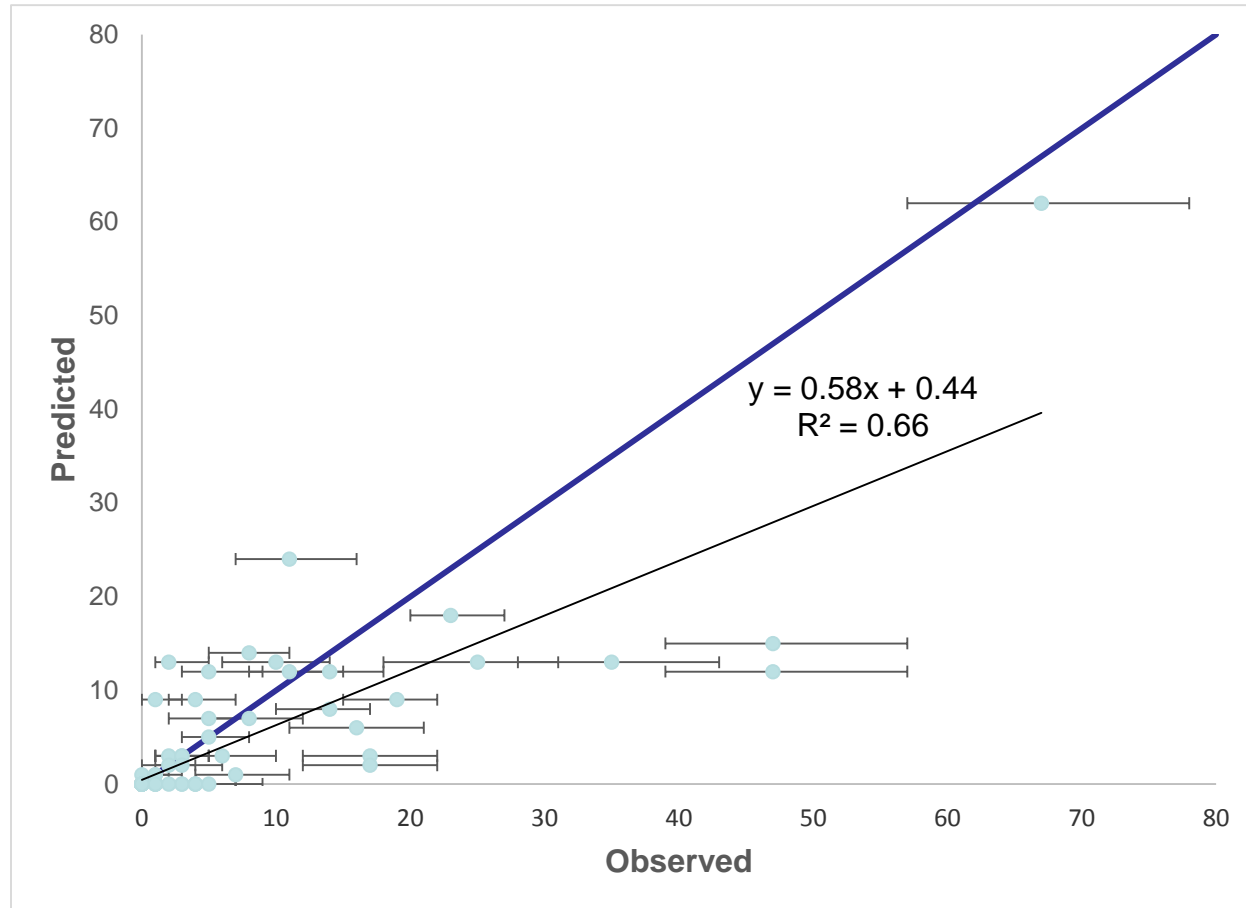


# EVAC/LOCL - Counts



	Predicted Number	90% Confidence Interval
EVAC	0	(0, 1)
LOCL	0	(0, 0)

# Medical Condition Counts



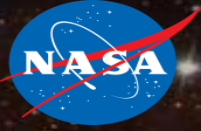
	Estimate	Confidence Interval
Intercept	0.44	(-0.38, 1.26)
Slope	0.58	(0.52, 0.66)

Individual condition counts were compared to the predicted simulation intervals to classify the conditions into the following performance determinations:

- **FAIL** – The observed number of events is not within the 90% simulation intervals for the predicted counts of the condition.
- **PASS** – The observed number of events is within the 90% simulation intervals for the predicted counts of the condition and has happened at least once inflight.
- **INDETERMINATE** – The condition has not been observed inflight and 0 is within the 90% simulation intervals for the predicted counts of the condition.

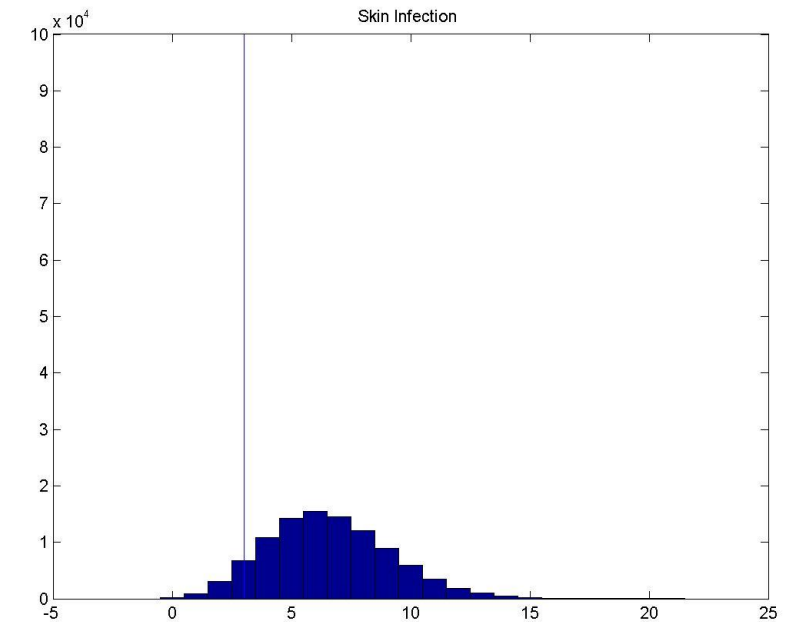
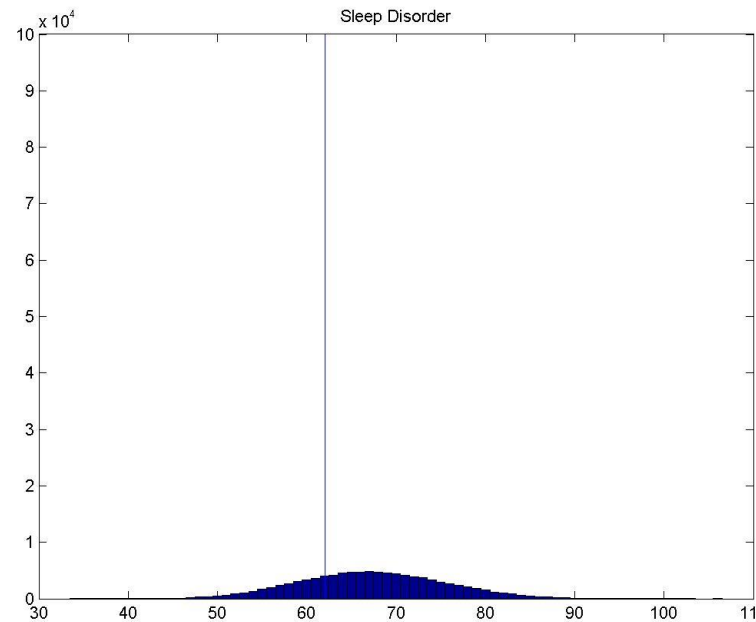
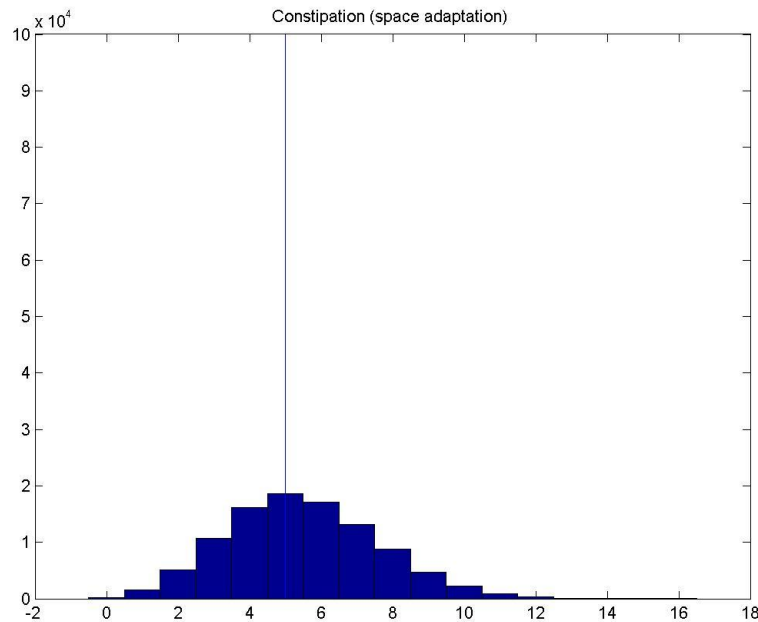


# Individual Condition Counts - PASS

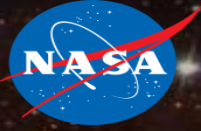


## 15 condition met the performance characterization criteria

- Constipation (SA), Eye Infection, Fingernail Delamination (EVA), Headache (CO<sub>2</sub> induced), Headache (SA), Hemorrhoids, Indigestion, Insomnia (SA), Neck Sprain/Strain, Otitis Media, Paresthesias, Shoulder Sprain/Strain, Skin Infection, Sleep Disorder, Wrist Sprain/Strain

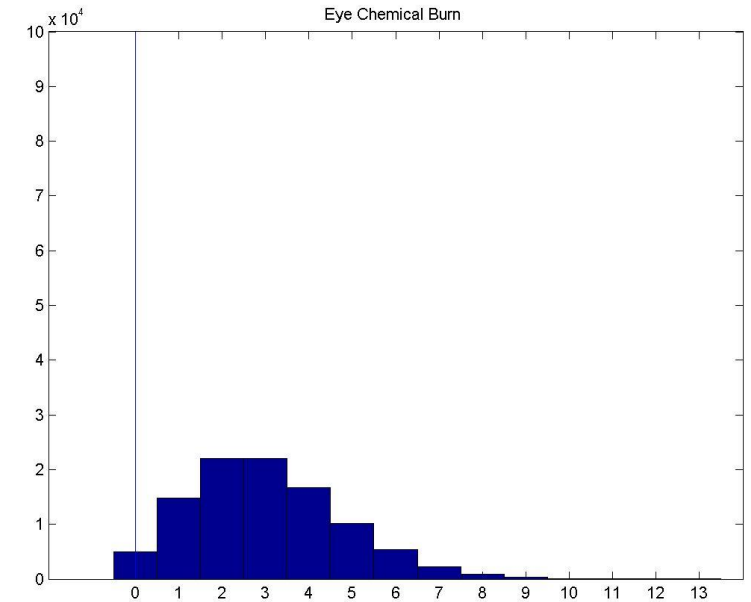
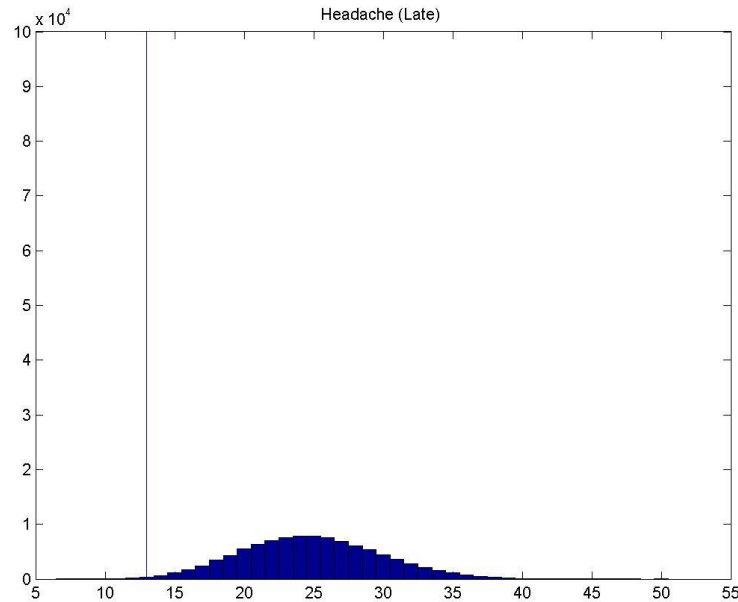
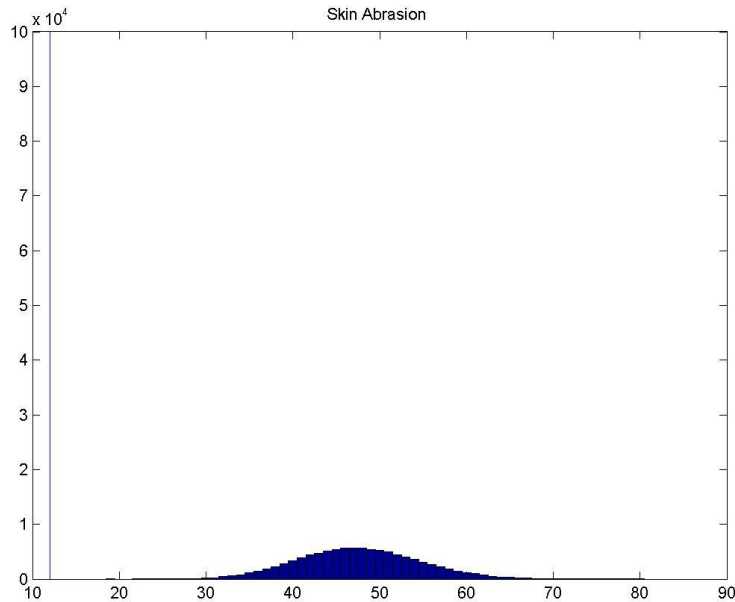


# Individual Condition Counts - FAIL

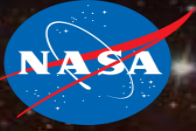


**24 conditions failed to meet the performance characterization criteria (17 over-predicted and 7 under-predicted the number of events)**

- Acute Sinusitis, Allergic Reaction (Mild to Moderate), Ankle Sprain/Strain, Anxiety, Back Pain (SA), Back Sprain/Strain, Barotrauma (Ear/Sinus Block), Dental Caries, Diarrhea, Elbow Sprain/Strain, Eye Chemical Burn, Eye Irritation/Abrasian, Headache (Late), Hip Sprain/Strain, Knee Sprain/Strain, Mouth Ulcer, Nasal Congestion (SA), Pharyngitis, Respiratory Infection, Skin Abrasion, Skin Rash, Space Motion Sickness



- **Total Number of Medical Events** accumulated over the entire set of missions significantly over-predicted when compared to the observed.
- **TME broken out over missions:**
  - Passed regression coefficient assessments
  - Seems to over-predict missions by 2-3 events
- **TME broken out over conditions:**
  - Slope did not include 1 showing some over-prediction
  - $R^2$  value shows reasonable agreement
- **Individual Conditions:**
  - 15 conditions passed the performance characterization assessment
  - 61 conditions could not be fully assessed due to sample limitations but otherwise predictions were not inconsistent with the 0 observed events
  - 24 conditions failed the performance characterization assessment with 17 over-predicting and 7 under-predicting the number of observed events



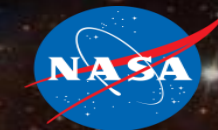
# **BACKUP SLIDES**

## **61 condition met the performance characterization criteria but had not occurred during the missions examined**

- Abdominal Injury, Abdominal Wall Hernia, Abnormal Uterine Bleeding, Acute Angle-Closure Glaucoma, Acute Arthritis, Acute Cholecystitis/Biliary Colic, Acute Compartment Syndrome, Acute Diverticulitis, Acute Pancreatitis, Acute Prostatitis, Acute Radiation Syndrome, Altitude Sickness, Anaphylaxis, Angina/Myocardial Infarction, Appendicitis, Atrial Fibrillation/Atrial Flutter, Behavioral Emergency, Burns Secondary to Fire, Cardiogenic Shock Secondary to Myocardial Infarction, Chest Injury, Choking/Obstructed Airway, Decompression Sickness (EVA), Dental: Exposed Pulp, Dental: Abscess, Dental: Avulsion (Tooth Loss), Dental: Crown Loss, Dental: Filling Loss, Depression, Elbow Dislocation, Eye Corneal Ulcer, Eye Penetration (Foreign Body), Finger Dislocation, Gastroenteritis, Head Injury, Hearing Loss, Herpes Zoster Reactivation (Shingles), Hip/Proximal Femur Fracture, Hypertension, Influenza, Lower Extremity (LE) Stress Fracture, Lumbar Spine Fracture, Medication Overdose/Adverse Reaction, Nephrolithiasis, Neurogenic Shock, Nose Bleed (SA), Otitis Externa, Retinal Detachment, Seizures, Sepsis, Shoulder Dislocation, Skin Laceration, Small Bowel Obstruction, Smoke Inhalation, Stroke (Cerebrovascular Accident), Sudden Cardiac Arrest, Toxic Exposure: Ammonia, Traumatic Hypovolemic Shock, Urinary Incontinence (SA), Urinary Retention (SA), Vaginal Yeast Infection, Wrist Fracture



# Individual Condition Counts - INDETERMINATE



**61 condition met the performance characterization criteria but had not occurred during the missions examined**

