National Aeronautics and Space Administration

SENSITIVITY ANALYSIS OF THE INTEGRATED MEDICAL MODEL FOR ISS PROGRAMS

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IMM v4.0 Overview

- **Consider data for 100 medical conditions from the Integrated Medical Evidence Database (iMED)**
- **Simulate medical event occurrences over large number of missions via Monte Carlo methodology**
- **For each medical condition:**

Results Robustness

- **Best practices with computer modeling includes establishing the robustness of the model**
- **Robustness is the determination of how thoroughly the sensitivities of the model results to the variables and parameters of the model are known**
- **Infers an understanding of the sensitivity of the real-world system to potential changes in the variables and parameters of the system**
  - Assuming the imitated system behaves like the real-world system
- **Understanding the relative importance of variables and parameters, along with the relative ability to affect those variables and parameters, improves decision making**

Sensitivity Analysis Methodology

- **Saltelli: "Sensitivity Analysis is the study of how variation in the output of a model can be apportioned, qualitatively or quantitatively, to different sources of variation (input) and how the given model depends upon the information fed into it."**

- **Partial Rank Correlation Coefficient (PRCC) Analysis**
  - Provides the linear relationships between two variables (one input parameter and one output parameter) when all linear effects of other variables are removed after rank transformation
  - Rank Transformation: transforms non-linear monotonic relations to linear

- **SRRC – Description goes here**
  - Standardized regression-based coefficients measure the sensitivity of each input on each output, adjusted for all the other inputs
  - Rank Transformation: transforms non-linear monotonic relations to linear

Contributing versus a sensitive parameter

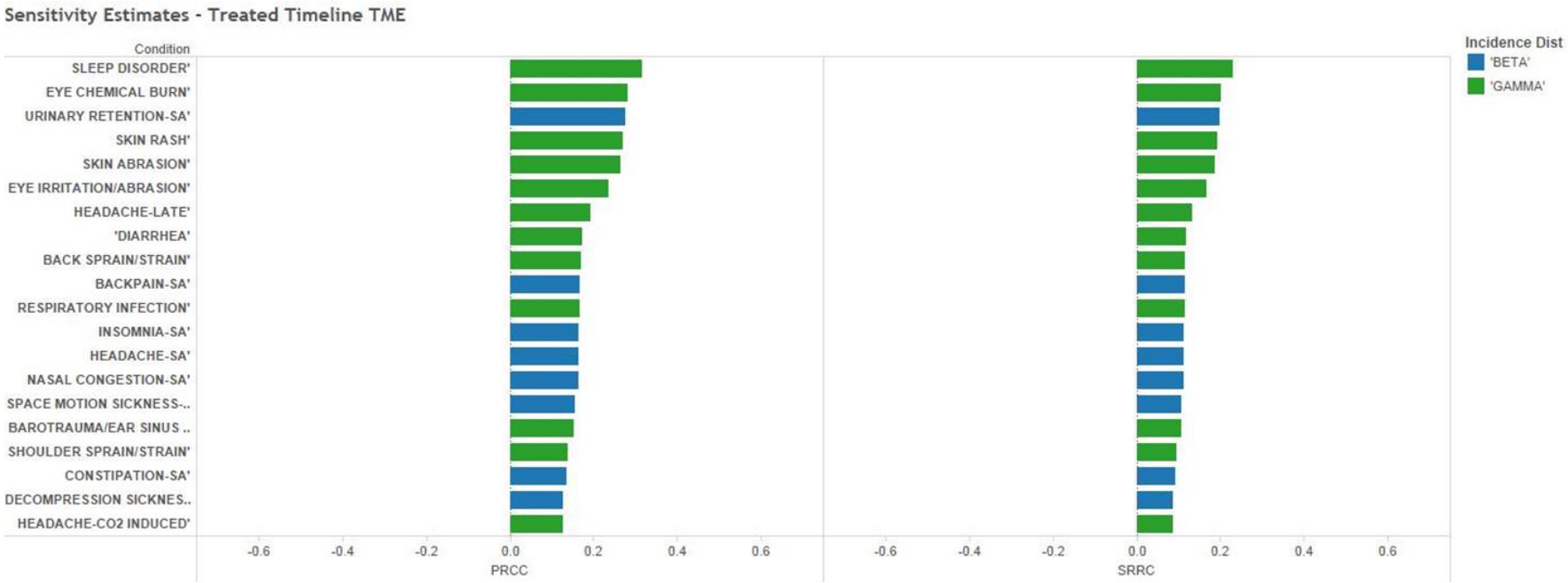
- ***KEEP IN MIND*** **the difference between an influential condition and a sensitive condition**
  - Many conditions contribute substantially to the mean output of the model
    - Low sensitivity may indicate a “DC-signal effect” over the range of model application and parameter variance
    - Example: VIIP and EVAC
  - Parameter variance affecting model output (magnitude and variance) indicates a sensitive parameter

Using IMM for ISS missions

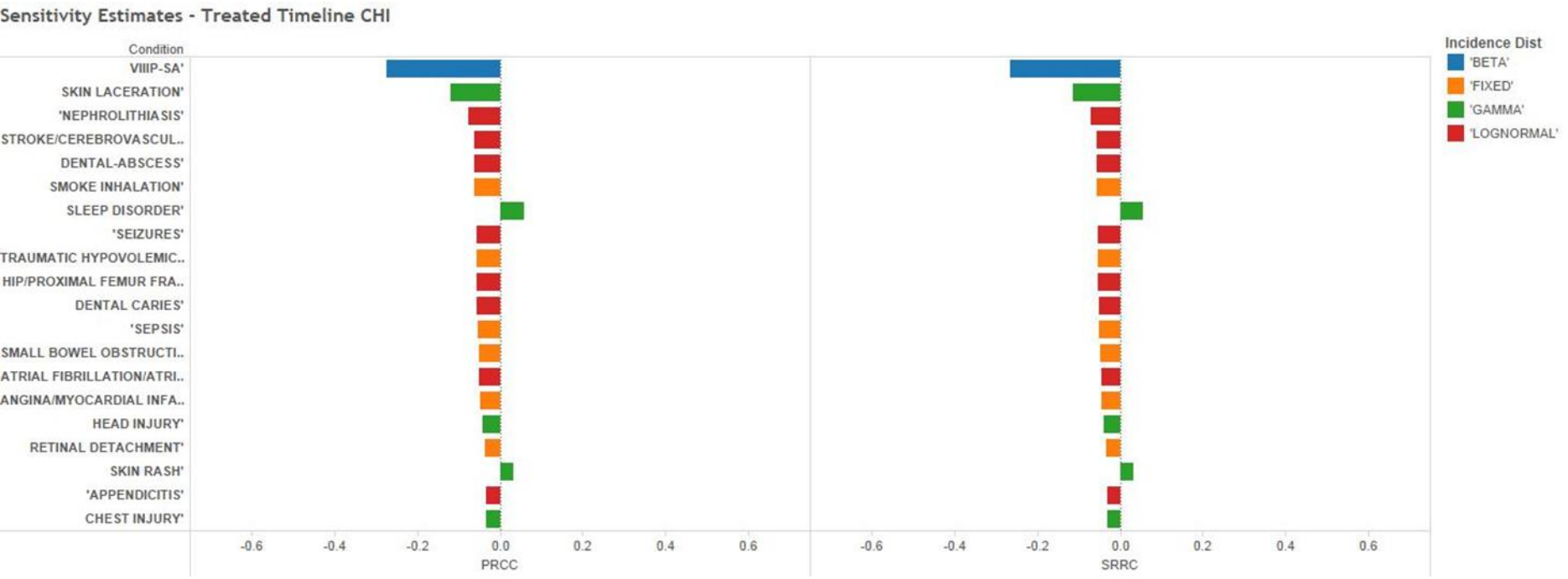
- **IMM Provides probabilistic analysis of 100 medical condition occurrences and impact to mission outcomes**
- **Context : 32 person-missions representing ISS person-missions of NASA astronauts Expedition 14 and later; also used in RWS validation**
- **Output:**
  - Total Medical Events
  - Crew Health Index (crew available time – time lost due to medical events)
  - Evacuation
  - Loss of crew life

$$CHI = \left(1 - \frac{QTL}{L}\right) \cdot 100\%$$

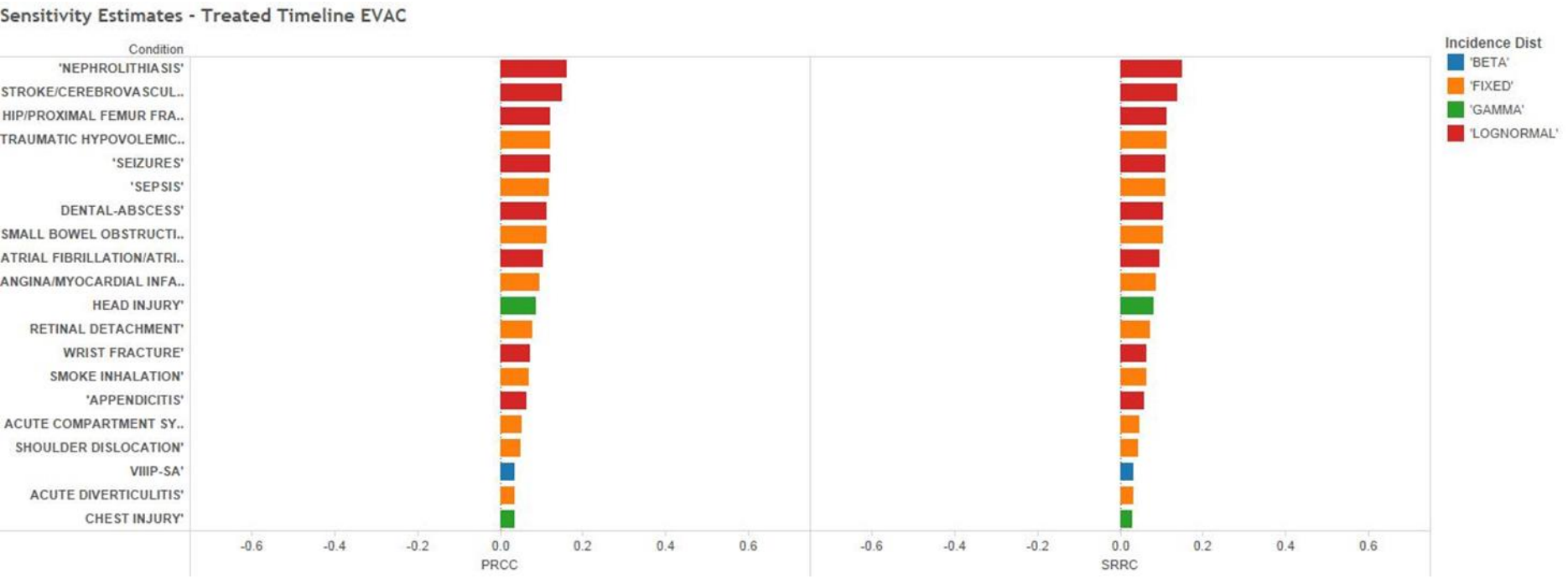
Total Medical Events



Crew Health Index

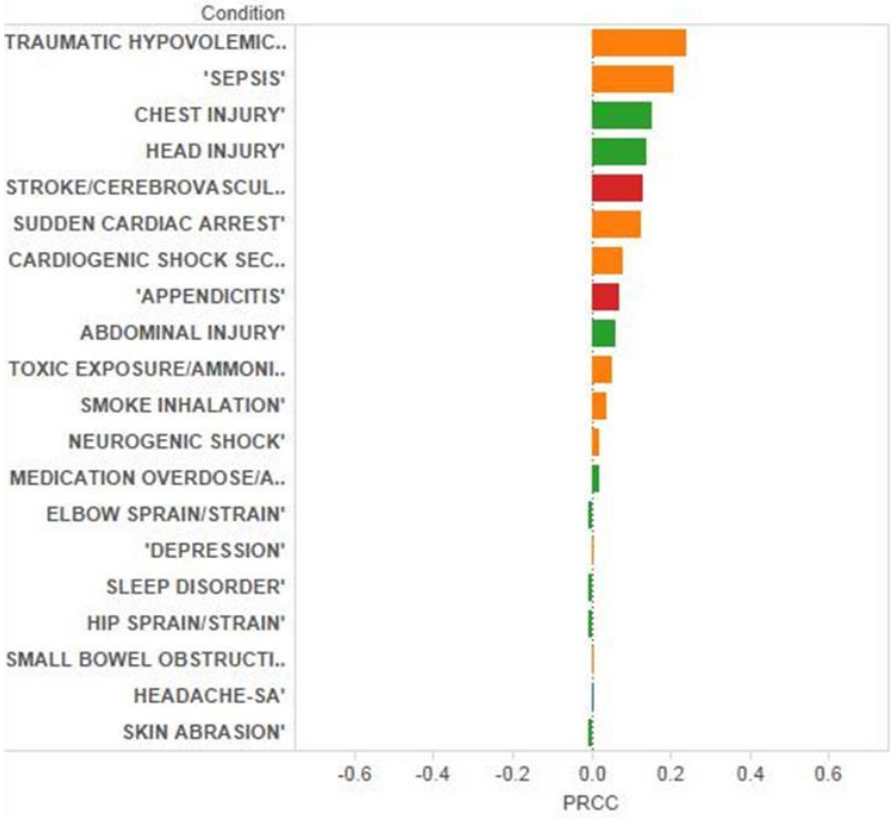


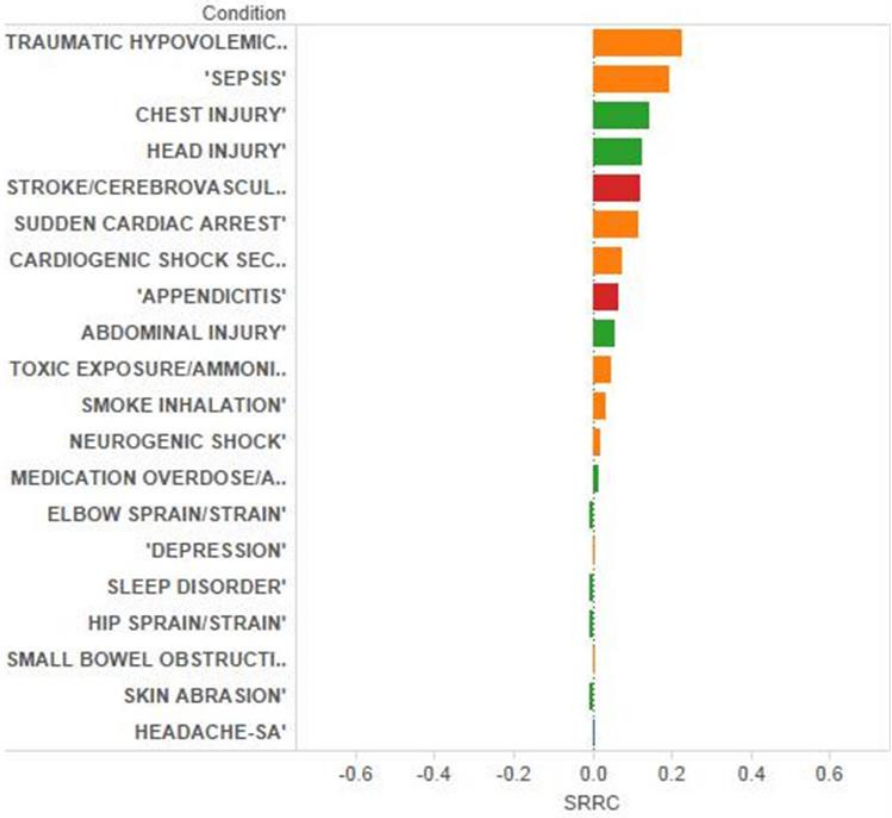
Consideration of Evacuation



Loss of Crew Life

Sensitivity Estimates - Treated Timeline LOCL





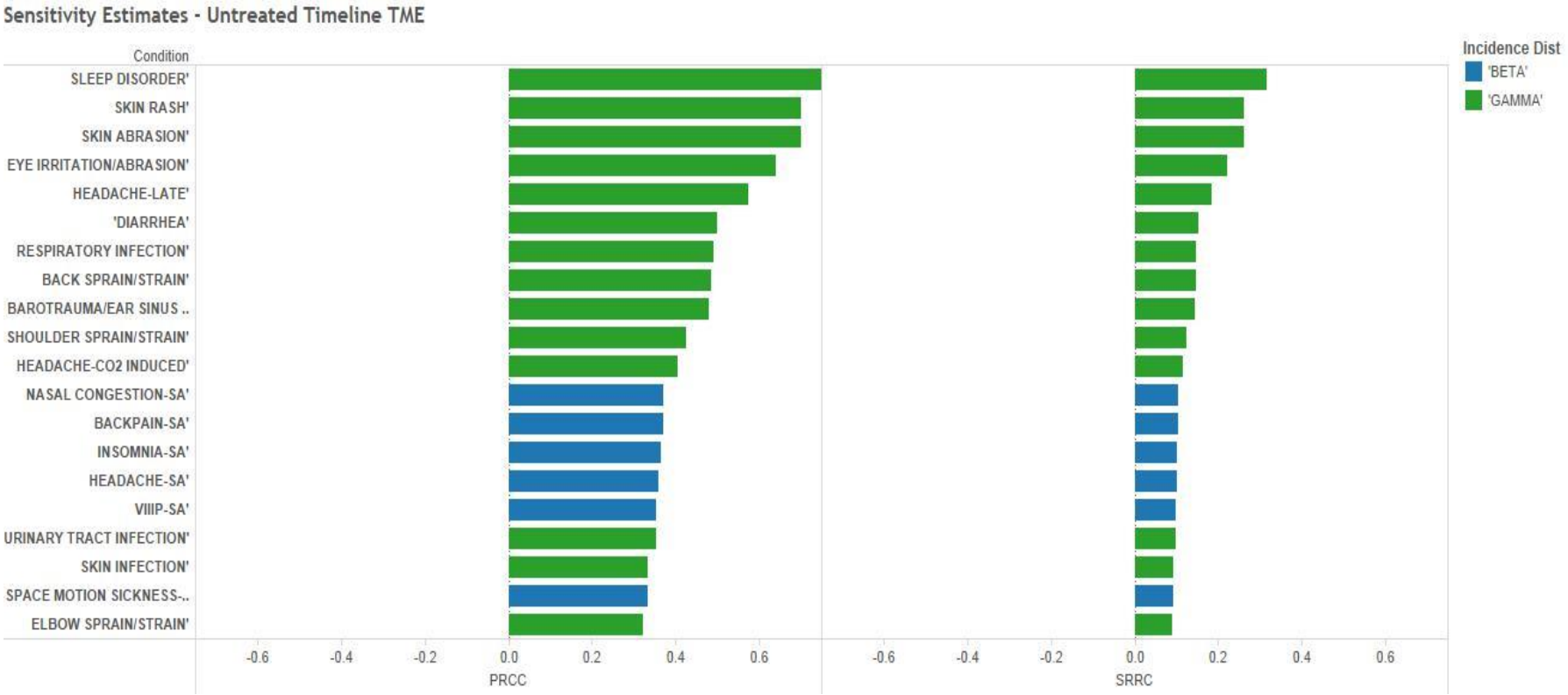
Conclusions

- **Successfully implemented a rigorous quantification of model sensitivity to parameter uncertainty**
  - Differs from and augments influential conditions estimate currently used by IMM
- **Many sensitive conditions in the CHI, EVAC, and LOCL cases do not appear in the sensitivity estimates of the total number of medical events**
  - these conditions having a low incidence rate, so the effect on TME is minimal
  - have a large effect such as prolonged impairment, evacuation, or death

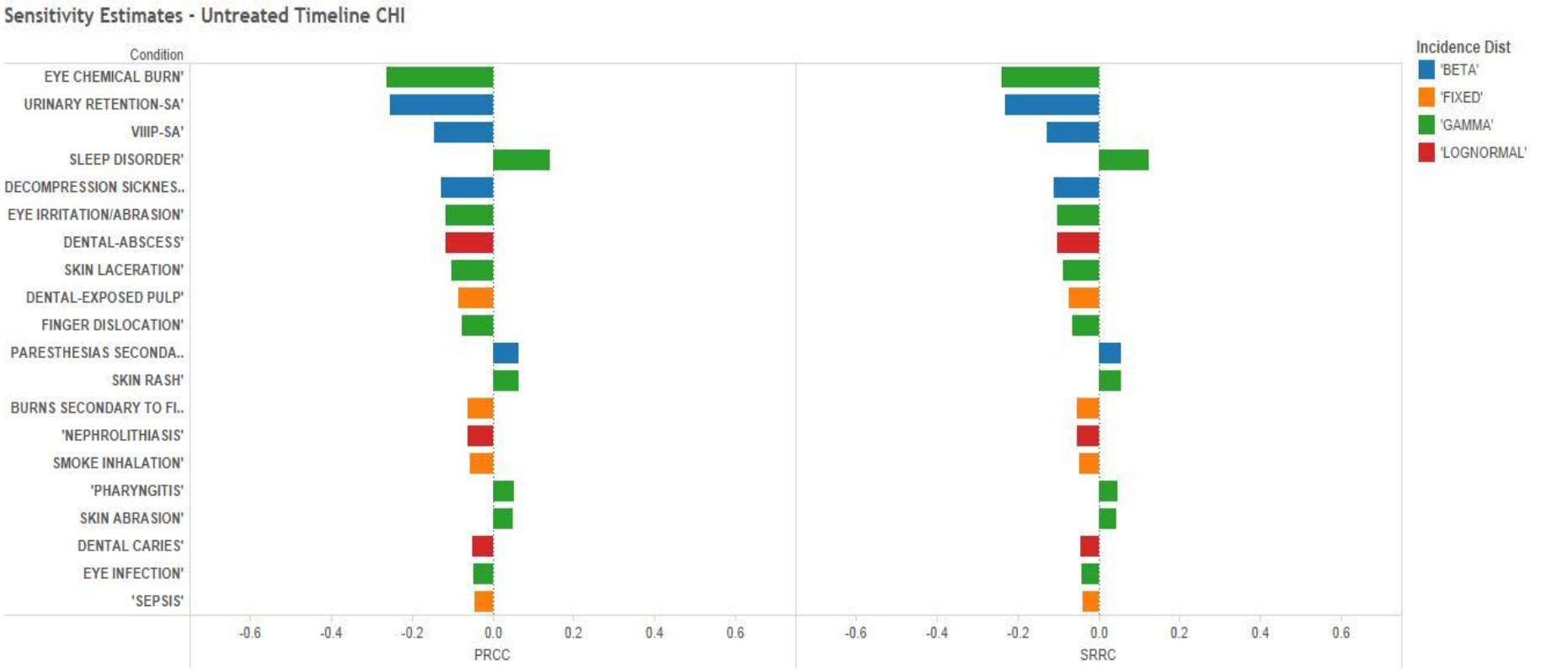
Thank you!

Questions?

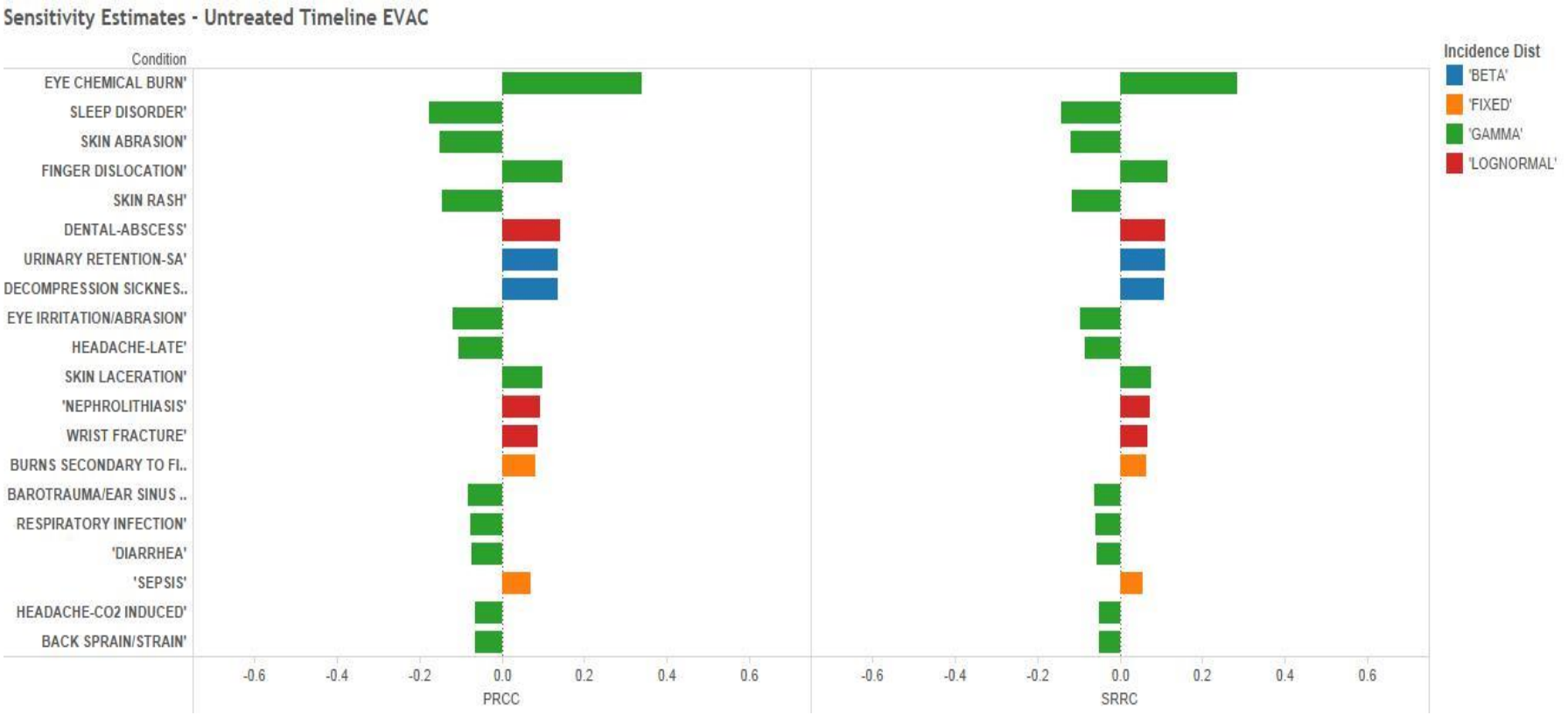
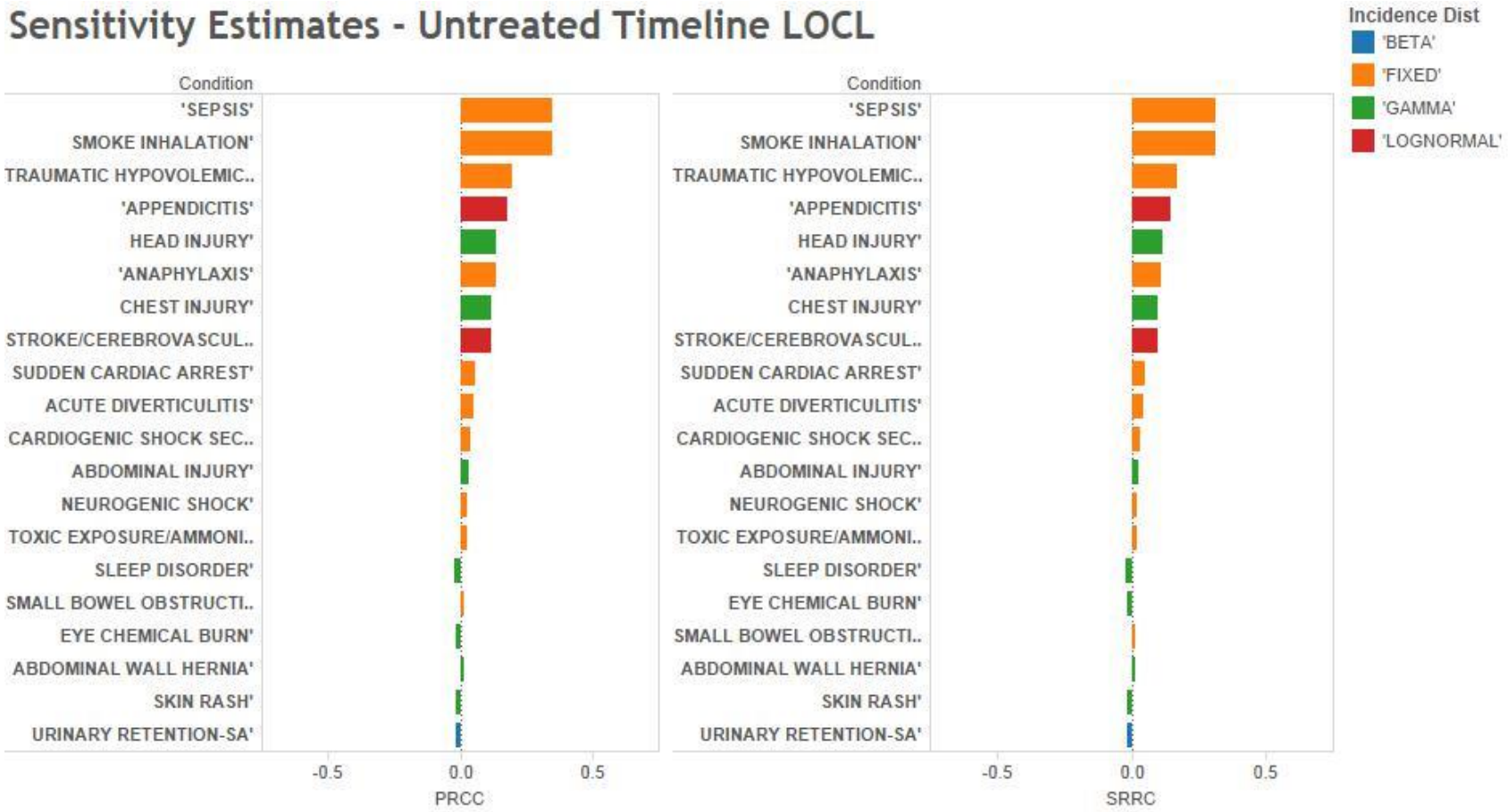
Backup- Untreated Total Medical Events



Untreated Crew Health Index



Untreated Consideration of Evacuation



Untreated Loss of Crew Life