National Aeronautics and Space Administration

Development of an Accepted Medical Condition List for Mars Transit Medical Capability Scoping

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Objectives

- To discuss the need for an accepted medical condition list for deep space missions.
- To describe what currently exists with regards to deep space-related medical condition lists and its limitations.
- To describe the methodology for a repeatable, evidence-based approach by which to create and/or update a medical condition list for deep space missions.
- To describe the results of this repeatable, evidence-based approach for creating and/or updating a medical condition list for deep space missions.

Need for Process to Develop Medical Condition List

- Will assist in identifying high priority medical conditions to plan for during deep space missions.

- Based on probability of occurrence, severity of disease, likelihood of successful treatment, and amount of resources required to manage.

- Will drive decisions related to what medical resources/capability will be available aboard future deep space vehicles.

- May also drive research related to the development of future spaceflight-related medical technologies.

What Currently Exists - IMCL

- **Derived from:**
  - the International Space Station (ISS) Integrated Medical Group (IMG) Medical Checklist (JSC-48522)[4]
  - the Flight Data File Medical Checklist (JSC-48031)[5]
  - In-flight medical incidence data in the Lifetime Surveillance of Astronaut Health (LSAH) repository
  - NASA Flight Surgeon subject matter expertise.

IMCL Limitations

- **Small sample size**
  – May not accurately represent probabilities.
- **May miss conditions if:**
  – Haven’t arisen by chance
  – Are not adequately anticipated by SMEs.
- **May overestimate likelihood of some conditions if:**
  – Arise with high frequency by chance.
  – Misperceived as a large concern by SMEs.

Methods

- **IMCL was used as starting point for discussion.**
- **The probability of occurrence for various conditions were based upon data from IMM run SR-20170306-376.**
  - Mars Transit DRM
  - Used a 4 crew (2 male, 2 female) profile
  - 16-month DRM
  - No EVA activity.
- **6 EVA related conditions were initially excluded but then reintroduced with change to Cis-Lunar DRM.**
- **Cis-Lunar DRM:**
  - 4 crew (all male
  - 42 day DRM
  - No EVA activity

What is the Integrated Medical Model?

- **Probablistic Risk Assessment (PRA) using Monte Carlo methodology**
- **Used to assess mission risk due to in-flight medical events**
- **Considers relevant preexisting medical conditions**
- **User defined Design Reference Missions (DRM) (eg. crew, duration, EVA, etc.)**
- **Considers outcomes for 100 medical conditions that have or may occur in-flight**
- **Incidence data from spaceflight medical events, and analog and general populations**
- **20 of 100 conditions have sex-dependent outcomes**

Methods

Complexity Key	*Score*	*Clinical Definition*
High	1	Large number of resources required to dx and tx or difficult management. (i.e. worst case sepsis)
Medium	0.1	Moderate number of resources required
Low	0.01	Small number of resources required (i.e. best case mild headache)

Futility Key	*Score*	*Clinical Definition*
High	1	Highly likely to result in death or disability despite treatment
Medium	0.1	Somewhat likely to result in death or disability despite treatment
Low	0.01	Unlikely to result in death or disability

Methods

Medical Condition	Case	Probability S-20170306-376	Futility	Complexity	Exclusion Score	Plan to Treat	Rationale / Conditions / (
TOXIC EXPOSURE (AMMONIA)	Best	0	0.1	1	N/A	Yes, with conditions	Initial ABC treatment only,
ANAPHYLAXIS	Worst	1.30762E-05	1	1	7.65E+04	No	All anaphylaxis will be appı
SUDDEN CARDIAC ARREST	Best	3.57632E-05	1	1	2.80E+04	Yes, with conditions	Limited to bag valve mask v external defibrillator, Intra lasting <45 minutes
ACUTE ANGLE-CLOSURE GLAUCOMA	Worst	4.46883E-05	1	1	2.24E+04	No	
ACUTE PROSTATITIS	Best	0.01213786	0.1	0.01	8.24E-02	Yes	
LOWER EXTREMITY (LE) STRESS FRACTURE	Worst	0.029007037	0.01	0.1	3.45E-02	Yes	Treatment is limited to sup
SMALL BOWEL OBSTRUCTION	Best	0.005582118	0.01	0.01	1.79E-02	Yes	
RESPIRATORY INFECTION	Best	0.983416095	0.01	0.01	1.02E-04	Yes	
SKIN RASH	Best	0.994999989	0.01	0.01	1.01E-04	Yes	

Methods

- Calculated Exclusion Scores were assessed by Element Scientist.
- Each condition was assessed with regards to "Should Plan to Treat" or "Should Not Plan to Treat".*
- Then the Medical Expert Group was asked to assess the outcomes determined by the Element Scientist and agree or disagree (as well as provide rationale for decisions).
- Where the Group disagreed, the final decision was made by the Element Scientist.

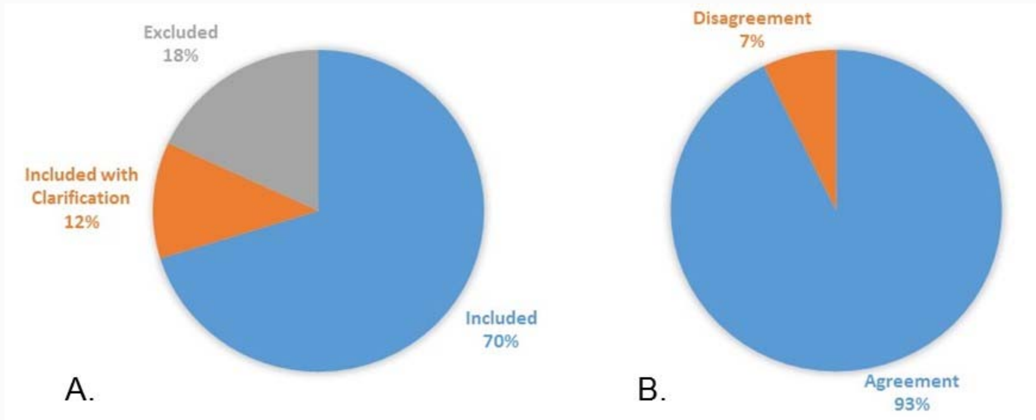
Methods

- Subsequently, the medical list was further refined by attaching medical resources/capabilities to each of the conditions.
- Medical resources and capabilities were attached to each condition by the panel of space medicine SMEs by incorporating their experience and understanding of what is considered "best terrestrial practice" for the treatment of each condition, but modified to take into consideration what are expected to be spaceflight-associated limitations on medical capabilities.
- This information was then used by the same medical professionals to further order and refine which conditions would and would not be treated.
- This incorporated a dimension of "resource requirements" to previous assessments of complexity, futility, and probability.

Results

- There were 194 conditions considered for the initial pilot project design.
- 135 were listed as "*Should Plan to Treat*" for medical system scoping with no dissent.
- 22 conditions were listed as "*Plan to Treat, with Conditions*".
- 34 conditions were excluded from consideration for system scoping by consensus, designated as "*Should Not Plan to Treat*".

Results


Excluded
18%
Included with
Clarification
12%
Included
70%
A.
Disagreement
7%
Agreement
93%
B.

Limitations

- Futility and Complexity are subjective (and thus impacted by individual clinician biases).
- Decisions made by Element Scientist (including final, tie-breaking decisions) were not externally validated.
- “Best Case Scenario” and “Worst Case Scenario” definitions were often limited and do not represent the whole spectra of clinical sequelae for a given disease.
- This methodology focused on exclusion of conditions from mission planning and thus started from a baseline list of possible conditions.

Future Directions

- Better delineating terminology.
- Future efforts should consider the broader range of disease manifestations, as well as clinical sequelae of different conditions.
- Refine the model to better define and objectively determine which conditions warrant resource allocation (eliminate subjectivity and SME opinion.)
- Otherwise, provide opportunity to externally validate subjective opinions.
- Building in an uncertainty factor into the medical capabilities for future missions to account for conditions that are missing or unexpected.
- Weighing the relative risk of various medical conditions from an ethical viewpoint, including acknowledgement of uncertainty in risk prediction for exploration missions.

References

- K. M. Gilkey, J. G. Myers, M. P. McRae, E. A. Griffin, and A. S. Kallrui, “Bayesian Analysis for Risk Assessment of Selected Medical Events in Support of the Integrated Medical Model Effort,” Jul. 2012.

- A. Keenan *et al.*, “The Integrated Medical Model: A probabilistic simulation model predicting in-flight medical risks,” International Conference on Environmental Systems, Bellevue, WA, ICES-2015-0022114, 2015.

- S. D. Watkins, “Space Medicine Exploration: Full Medical Condition List.,” National Aeronautics and Space Administration, Washington, DC, NASA/TP-2010-216118, 2010.

- Medical Operations Directorate, Operations Division, “International Space Station Integrated Medical Group (IMG) Medical Checklist,” National Aeronautics and Space Administration, Johnson Space Center, NASA/JSC-48522-E4, 2001.

- Mission Operations Directorate, Operations Division, “Space Shuttle Program Flight Data File Medical Checklist,” National Aeronautics and Space Administration, Johnson Space Center, NASA/JSC-48031, 2006.