The Integrated Medical Model

Statistical Forecasting of Risks to Crew Health and Mission Success

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Overview

The Integrated Medical Model (IMM) helps capture and use organizational knowledge across the space medicine, training, operations, engineering, and research domains. The IMM uses a data model to rapidly access and organize knowledge in the context of a mission and crew profile to forecast crew health and mission success rates. The IMM is most helpful in determining the risk of two or more mission-profiles, not as a tool for predicting absolute risk.

IMM Capabilities

- Assesses 1,000+ Medical Conditions
- Forecasts crew health and mission success rates
- Tracks mission capability and availability
- Acts as a database for medical conditions
- Helps guide mission planning

Methods

Establishing a List of Relevant Medical Conditions – A baseline list of medical conditions serves as the IMM clinical modeling roadmap and is required to manage the scope of the project. The current baseline list of Medical Conditions (BLM) – derived from the ISS Medical Checkup – covers approximately 75 conditions, most of which have occurred during past space flights.

Establishing incidence rates – The IMM incidence rate (defined as events/person-year) for each condition is calculated using the ISS Medical Checkup data and the Longitudinal Study of Astronaut Health (LSAH) Database. If resources were unlimited and treatments were 100% effective, a prediction of the most probable outcomes can be generated. For each “mission”, the IMM tracks which conditions occurred and determines the pharmaceticals and supplies required to diagnose and treat these medical conditions. If supplies are depleted, then the mission condition goes untreated, and crew and mission risk increase.

Establishing Metrics for Crew Health Risk – The IMM uses this domain knowledge in the context of a mission and crew profile to forecast crew health and mission success risks. The IMM is most helpful in determining the risk of two or more mission-profiles, not as a tool for predicting absolute risk.

Key Assumptions, Inaccuracies

- The IMM views the mission from the point of view of the mission debrief. This means the mission is viewed as if it was already completed. What happened during the mission is not tracked. We experimented with tracking each day and building a mission log, but it turned out to be very complex and not very helpful.
- The IMM model currently models 37 disorders, however only a few conditions have assigned diagnosis and treatment protocols so the follow-up forecasts are offered as examples only.
- Each forecast represents 10,000 mission simulations, with one male and one female crew member (two crew total).

Validation

- Clinical – Clinical validation is a multi-faceted, continuous effort. Data is initially derived from NASA’s Medical Checkup (ISS) database, then reviewed by Space Medicine Subject Matter Advisors, and finally Independent Clinical Reviewers. The validation process would also analyze the accuracy of the tasks and resources required to diagnose and treat each condition.
- Statistical – Statistical validation is currently a three-phased effort. Phase I ensures the correct distributions have been assigned to all model assumptions. Phase II tests the model with extreme values. Phase III compares predicted forecasts with empirical data if available.

IMM Output – Examples

The IMM currently models 37 disorders, however only a few conditions have assigned diagnosis and treatment protocols so the follow-up forecasts are offered as examples only. Each forecast represents 10,000 mission simulations, with one male and one female crew member (two crew total).

Summary

The IMM will continue to add conditions and refine the clinical evidence base, and is on track to help risk-based decisions for medical systems and operational concepts for the Constellation Program. The IMM Project coordinates data mining and modeling activities with other Risk Management efforts such as the Exploration Medicine Element, Risk Assessment and Integration Team (RAIT), SD2/DSH Study, and Longitudinal Study of Astronaut Health (LSAH) Office.
The Integrated Medical Model (IMM) Project

• Overview – Statistical decision support tool for forecasting crew health and related mission risks, and optimizing the medical logistics “footprint” of in-flight crew medical systems

• Progress to Date
  – Established Baseline list of approximately 75 conditions
  – 37 medical conditions modeled
  – Defined Risk Metrics for crew and mission
  – Established Clinical Finding Form Template
  – Developed Resource Manager Software to track medical consumables
  – Compiled historical Review of Medical Events
  – Populating Resource Tables with unit quantity, mass, and volume
    Collaborating with USAARL to refine incident data with surrogate population data
  – Developing Clinical and Statistical Validations Plans
## IMM Key Milestones

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<th>FY2008</th>
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| △ Baseline Medical Conditions List  
△ Complete CLIFF's (72+ conditions)  
△ Model 72+ Conditions  
△ Integrate Resource Table (72+ conditions x2)  
△ Establish Statistical/Clinical Validation Plans  
△ Assess/Integrate USAARL data | | ✓ Initial roadmap established  
✓ Outcomes mapped to conditions and treatments  
✓ Initial assessments capable  
✓ Logistics mapped to risks  
✓ Baseline conditions list expanded via surrogate population data | |
| △ Incorporate Delphi Data (when available)  
△ Develop Database Integration Requirements  
△ Refine Loss of Mission (LOM) metric  
△ Initiate Statistical/Clinical Validation Plans  
△ Migrate CLIFF's to database  
△ 100+ conditions modeled (est.) | | ✓ Baseline conditions list +  
✓ Ensure knowledge capture  
✓ Refined comparative mission risk assessments  
✓ Efficient, current modeling  
✓ Prep. for database integration  
✓ Increased confidence levels | |
| △ Complete Initial Validation  
△ Expand Risk Factors  
△ Database Integration  
△ 120+ conditions modeled | | ✓ Validated planning tool  
✓ Increased crew/mission modeling fidelity  
✓ Efficient, current modeling with HITT/PCDB  
✓ Increased confidence levels | |