NASA Biomedical Informatics Capabilities & Needs

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- **Mission Statement**
  - To improve on-orbit clinical capabilities by developing and providing operational support for intelligent, robust, reliable, and secure, enterprise-wide and comprehensive healthcare and biomedical informatics systems with increasing levels of autonomy, for use on Earth, low Earth orbit & exploration class missions.

- **Biomedical Informatics**
  - Biomedical Informatics is an emerging discipline that has been defined as the study, invention, and implementation of structures and algorithms to improve communication, understanding and management of medical information.
  - The end objective of biomedical informatics is the coalescing of data, knowledge, and the tools necessary to apply that data and knowledge in the decision-making process, at the time and place that a decision needs to be made.
Biomedical Informatics @ NASA

- Evidence Base Collection and Coding
- Evidence Base Analysis
- Clinical Decision Support Systems
- Other Decision Support
- Data Visualization
- Data/Information/Knowledge Search and Retrieval
Evidence Base = 50 Years of Spaceflight Data
What Data Does NASA Have?

**Life Science Data Archive (LSDA)**
- Contains *research data* from NASA-funded experiments, primarily data from flight experiments and ground analog data collected at NASA facilities
- [http://lsda.jsc.nasa.gov](http://lsda.jsc.nasa.gov)

**Longitudinal Study of Astronaut Health (LSAH)**
- Contains electronic health records (*medical data*) of all astronauts, including mission data
- Data are collected for clinical purposes
- Clinical data are analyzed by LSAH epidemiologists to identify trends in crew health and implement changes in pre-, in-, or post-flight medical care
Evidence Base Collection & Coding

Capabilities:
- Ease of data collection
  - Integrated with standard operations
  - Electronic Medical Record for clinical
  - Sharepoint Repository for additional info
- Enablers for data analysis
  - Standardized terminologies: SNOMED & MESH
  - Structured data entry
  - Centralized data repository

Challenges:
- Predict metadata, ease of structured/coded data entry, more automated encoding
Evidence Base Analysis

Capabilities:
- Team of epidemiologists
- SAS software and JMP visualization tools

Challenges
- Small “n” especially for long duration missions
- Comparability of data elements
  - Tests and collection techniques have changed over the years
- Datasets to use for comparison
  - Analog population identification – subjects are healthier than average
Clinical Decision Support

- **Capabilities**
  - **Ground**
    - Through modules in EMR
  - **Flight – Flight Surgeon**
    - EMR support
    - Issue tracking in Sharepoint
  - **Flight – Astronaut Crewmember**
    - Data Collection programs, remote guidance from ground
Inflight Clinical Decision Support Challenges

- Training of the personnel providing medical care on board the space craft
  - Even if a physician is on board, what would happen if that person were ill or injured?
- Limited size and capability of the medical kit
- Time delay in communication with ground support personnel
  - Up to 45 minutes round trip to Mars
Exploration Class
Medical Decision Support Systems Goals

- On-board medical decision support systems can mitigate some of the challenges

- Functions:
  - Just-in-time training (generate the skill set as needed)
  - Refresher medical training (keep the skill set available)
Exploration Class
Medical Decision Support Systems

- Functions:
  - Guided procedure execution
  - Automatic generation of status reports for ground personnel for both nominal and contingency situations
  - Consumables tracking
  - Medical monitoring for trends
Medical Decision Support Systems
Keys to Success

- Ability to update the on-board procedures from the ground for the specific conditions and medical events as they occur in non-emergency scenarios.
- Integration of all aspects of the system – data, HW, human
Non-clinical Decision Support

- Support for requirements generation
- Capability = Integrated Medical Model (IMM)
IMM Project Goals

- To develop an integrated, quantified, evidence-based decision support tool useful to crew health and mission planners

- To help align science, technology, and operational activities intended to optimize crew health, safety, and mission success
Scope and Approach

**IMM addresses in-flight risk only, and uses ISS data as stepping stone**

**Scope**
- Forecast medical outcomes for in-flight operations only
- Forecast medical impacts to mission
- Does not assess long-term or chronic post-mission medical consequences

**Approach**
- Use ISS data as stepping stone to Exploration Program
- Employ best-evidence clinical research methods
- Employ Probability Risk Assessment (PRA) techniques
- Collaborate with other NASA Centers and Organizations
What is IMM?

- A software-based decision support tool
  - Forecasts the impact of medical events on space flight missions
  - Optimizes the medical system within the constraints of the space flight environment during simulations.
Who can benefit from IMM capabilities?

- **Flight Surgeons**
  - What in-flight medical threats are greatest for reference mission A?

- **Risk Managers**
  - What is the risk of evacuation - due to a medical event - for a 6-person, 180 day mission assuming the current in-flight medical capability?

- **Vehicle Designers**
  - What’s the optimum medical mass allocation for given level of risk?

- **Health Care System Designers**
  - What medical items do we fly for a given mass/volume allocation?

- **Trainers**
  - How do I prioritize limited crew training hours?

- **Requirement Managers**
  - What’s the rationale for this crew health requirement?
“What if...?” Questions

IMM is designed to help answer specific in-flight questions

Questions

- Is the current ISS medical kit adequate for a crew of 6 on a 6-month mission?
- Does a 33-day lunar sortie mission require a different Level of Care than a 24-day lunar sortie mission?
- Are we carrying enough Ibuprofen for a crew of six on a 12-month mission?
- How does risk change if the ventilator fails at the start of a 3-year mission?

Questions

- What is the probability of a bone fracture occurring 10-years after a 6-month mission?
- What is the probability of renal stone formation after a 12-month mission?
# IMM Conceptual Model

**INPUTS**
- Medical Conditions & Incidence Data
- Crew Profile
- Mission Profile & Constraints
- Potential Crew Impairments
- Potential Mission End states
- In-flight Medical Resources

**OUTPUTS**
- Medical Condition Occurrences
- Crew Impairments
- Clinical End States
- Mission End States
- Resource Utilization
- Optimized Medical System
Data Visualization

- **Current capability:**
  - Graphs and other display mechanisms pre-determined

- **Challenges:**
  - Dynamic generation of data visualization materials to support real-time problem solving
Search and Retrieval of Data/Information/Knowledge

- **Capabilities:**
  - Data/Information/Knowledge captured in many formats/applications – e.g. EMR, Sharepoint, file shares, etc.
  - Pilot project for a concept based search tool

- **Challenges:**
  - Searching across many collections of information
  - Finding relevant information easily
Summary

- Biomedical Informatics at NASA encompasses a broad range of activities
  - Clinical – data collection & analysis
  - Clinical decision support for ground and flight
  - Non-clinical decision support for requirements generation and assessment
  - Data visualization
  - Search & Retrieval of Data/Information/Knowledge