NASA Biomedical Informatics Capabilities & Needs

Kathy A. Johnson-Throop, PhD
Medical Informatics & Healthcare Systems Branch

July 8, 2009
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