Space Medical Technology Innovation and its Global Application

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Medical Support in Remote Areas

Wherever human beings live, medical support remains an essential life line for survival.

Outer space is one extreme example of a remote area where sophisticated equipment and devices, as well as, doctors and nurses are not always available.

In order to help many people, who are isolated and without even the most basic of health care, we need to look for more efficient methods to bring health care to those in need.
Discussion Topics

Space Medicine
1. Role of Space Medicine
2. Space Environment and its Influence on Health
3. Area of Space Biomedical Research
   - Example: in case of “JAXA Space Biomedical Research Office (J-SBRO)”
4. Medical Devices being used in the International Space Station (ISS)
   - Medical Systems
     a. Devices
     b. Communication Systems

Satellite Technology as a Medical Tool
1. Concept
   - Health Care on Public-level
2. Examples of Satellite Data for Health Care
Role of Space Medicine

- Medicine is essential for humans to live
  - Infrastructure for Human Space Exploration
  - Survival techniques for extreme environment
  - Occupational Medicine for the people working in space
  - Environmental Medicine (Public Health, Community Hygiene)

- Preventive medicine
  - For Space Explorers
  - For People Living on Earth

- Plays an important role for human beings to expand the activities from the earth to space
Space Environment and its Influence on Health

International Space Station (450 km above the earth)

Environment:
1. Microgravity
   • Balance Disorders
   • Cardiovascular Deconditioning
   • Decrease of Bone Mineralization
   • Muscle-Disuse Atrophy
2. Closed, confined, multi-cultural environment
   • Mental stress
   • Depression
   • Reduction in group dynamics
3. Cosmic radiation
   • Cancer risk
   • Reduction of immune response

Space environment affects on health
Space medicine is for ensuring health of people living and working in space

“War of the World” by H.G. Wells
Area of Research in JAXA Space Biomedical Research Office (J-SBRO)

Physiological Countermeasures
- Bone and Muscle
- Cardiovascular System

Psychological Support
- Stress Management

Medical Systems
- Devices
- Communication system

Environment of Spacecraft
- Off Gases
- Micro-organisms

Moon Base Frontier Medicine

International Space Station (ISS)
Medical Devises Being Used in the International Space Station

- Five partners operate ISS: NASA, Russia, ESA, CSA, JAXA
- NASA and Russia play a leading role of crew medical operations
- Catalogs for on-board medical facility and devices are developed
- Flight surgeons are responsible for crew health care
- Crew health care is operated from the Mission Control Centers which are remotely supported by the specialists in medicine and psychology

15 Participants Countries

ISS CHeCS Medical Hardware
- Countermeasures System
- Environmental Health System
- Radiation Monitoring
- Toxicology
- Health Maintenance System

ISS Russian Medical Hardware and Items
- Contents List of Medical Hardware
- Medical Control
- Prophylaxis
- Sanitary Hygiene and its support
- General Use
- Clothes, Underwear, Shoes
- Radiation Environment Monitoring Hardware
Requirement of Devices in Medical Systems

- General Characteristics:
  - User-friendly
  - Durable
  - Efficient
  - Compact
  - Light-weight
  - Safe
  - Longer Battery Life
  - Built-in Power Generator System
  - Built-in Diagnostic Capability

  - Self health care can be conducted without a health specialist.
  - Offering a range of essential treatment choices
  - Autonomous health care system is required by those individuals in very isolated areas like mars

Recent trend is to utilize commercially available devices as much as possible. “Spinning inn rather than spinning out”
Establish Communication Systems
Between Space and Ground Stations

Communication system can connect the people living in remote areas with medical professionals.

It enables:
tele-medicine
- monitor
- diagnosis
- therapy
- education
- consultation

The approach taken for developing medical systems in space programs have been used not only for supporting astronauts in space but also people living and working in remote areas on earth.

Global application of space technology can dedicate to health care on earth.
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**Satellite Technology as a Medical Tool**

1. Concept
   - Health Care on Public-level
2. Examples of Satellite Data for Health Care
Concept of Use Satellite Technology as a Medical Tool

----- Health Care on Public-level ----- 

Environmental information helps health care in public-level

**Space Medicine**
1. Health Care on Individual-Level
   - for Astronauts
   - for people on the earth

2. Health Care on Public-level
   - Dedication from Space Technology
     - Communication
     - Earth Observation

**Satellite Technology**
1. Communication

2. Earth observation
   1. Monitor
   2. Assessment
   3. Prediction, Prevention

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Ibuki (GOSAT)
Daichi
ISS
Aqua/AMSRE
Satellite Data for Health Issues

Air Quality and Aerosol Mapping
- Air pollution (PM, Ozone, NO\textsubscript{x}, SO\textsubscript{x}, etc.)
- Aerosol (Asian dust (Kosa))
- Green House Gas (GHG)

Vector’s Habitat/Transmission Route Characterization and Mapping
- Land Surface Temperature
- Precipitation
- NDVI (Normalized Difference Vegetation Index)
- Sea Surface Temperature
- Ocean Color

LULCC, DEM
Geographic Information System (GIS as base map)
Heat Wave in Europe, Aug. 2003

Left: Atmospheric temperature deviation in Aug. 2003 from 2002 derived from AMSR-E. Some spots are supposed to be false patterns due to radio interference.

Right: Sea surface temperature deviation in Aug. 2003 from 2002 derived from MODIS.

Deaths from Europe’s 2003 heat waves (heatstroke and excess mortality):
22,146 in Europe (14,802 in France and 3,134 in Italy)

Sources: WHO, 2004 report
Quoted Heat waves fact at a glance: www.ifrc.org/publicat/wdr2004/chapter2.asp
Iceland Volcano Smoke from Europe to Siberia.
Images: GOSAT/TANSO-CA, Wave Length: 870nm, 678nm, 380nm
April 15, 16, 17, 18, 2010

White: Clouds • Snow • Ice  Red: Land, Vegetation  Yellow: Volcano Smoke
Dust from Asian Continent

- 2.2% increase in mortality rate of senior citizens when Asian dust came flying in spring
- The rate of hospital admissions and out-patients increased in respiratory, circulatory, and ophthalmology departments

Korean Epidemiological surveillance from 1995 to 1998
Source: Ministry of the Environment, Government of Japan
JMA’s Activities on Asian Dust

JMA have been providing the Aeolian dust information since January 2004. MRI have been developing the numerical dust aerosol model.

Aeolian dust observation
Aeolian dust prediction

Japanese only

Number of Kosa observation

Basic information of Kosa
Map of duration in month with NDVI (Normalized Difference Vegetation Index) higher than 0.4 estimated from Vegetation Index Mosaic in 1977, East Asia (NIES)

Satellite data can be used for tracking and predicting malaria outbreaks

Analysis of Malaria Endemic Areas on the Indochina Peninsula Using Remote Sensing
Naoko Nihei, Mutsuo Kobayashi et al.
JPN.J.Infect.DIS.,55, 160-166,2002
Cyclone "NARGIS" reached Myanmar on May 2-3 2008
Flooding along Ayeyarwaddy River

WHO Report on May 29th 2008
http://www.searo.who.int/en/Section10/Section2535.htm#May29

Cyclone Nargis and communicable diseases
On day 26 of cyclone:
• 77,738 people dead
• 55 917 people missing.
• Cases of diarrhea and dengue fever are being investigated.
• Along with water-borne diseases, vector-borne diseases and acute respiratory infections (ARIs) remain a concern as these cases are expected to increase in the current rainy season.

Precipitation information from satellite data can be used for disease control

Blue parts indicate flooded areas
Yellow parts indicate non-flooded areas with soil moisture increasing.
Global Rainfall Map from TRIM Satellite during Cyclone "NARGIS" in Myanmar

TRMM (Tropical Rainfall Measuring Mission) satellite observes global precipitation distribution and contributes to understanding the mechanisms of climate change.

Near Real Time Global Rainfall Map on Web
http://sharaku.eorc.jaxa.jp/GSMaP/

Cyclone "NARGIS" reached Myanmar
JAXA provides Global Rainfall Map from Satellites
http://sharaku.eorc.jaxa.jp/GSMaP/

- produced 4 hours after observation
- and updated every hour

Internet access
- Images & Movies
- Google Earth files
- Data download
WHO Approach for utilizing Space Technology

Bulletin of the World Health Organization
http://www.who.int/bulletin/volumes/86/2/08-020208/en/

Space technology: a new frontier for public health

Satellite technologies are a natural ally in public health emergencies for tracking the extent of disease outbreaks and natural disasters.
GEO Health Projects

Implementation of a Malaria Early-Warning System

Monitoring and Prediction of Aerosol Impacts on Health and Environment

Global Monitoring Plan for Persistent Organic Pollutants

Global Monitoring Plan for Atmospheric Mercury

Air Quality Observations, Forecasting, and Public Information

Information Systems for Health

Meningitis Decision-Support Tool

Decision-Support Tools and Research on Ecosystems, Biodiversity, and Health
Conclusion

Space technology dedicates health care:

1. Medical technology derived from space medicine as a preventive medicine can be applied on earth.
   -----Individual-level approach-----

2. Satellite technology which provides earth observation information and global communication can also be a potent medical tool.
   -----Public-level approach-----