Space: A Healthcare Ecosystem

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Learning how to administer healthcare in space will improve healthcare on Earth
Adaptations to Spaceflight

- Vision
- Balance
- Behavior and Sleep
- Heart
- Muscles and Bone
Space as a Healthcare Ecosystem

Routine Health Surveillance is not routine!
• Non-invasive real-time diagnostics
• Autonomous/semi-autonomous care
• Clinical-decision support
• Telementoring
Space as a Healthcare Ecosystem

- On-site clinical lab analysis: blood, urine, saliva, stool
- Robust dependable technologies
- Simplified procedures
Space as Healthcare Ecosystem

Treatments:
Minimally-invasive
Limited available meds
Limited trauma-care

How do you administer CPR in Zero Gravity?
Medical Innovations for Space: Impact on Earth

<table>
<thead>
<tr>
<th>Feature for Space</th>
<th>Benefit on Earth</th>
<th>↑Access</th>
<th>↓Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small footprint (size, power, consumables)</td>
<td>Can be used in non-traditional settings</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Robust and reliable</td>
<td>Require no infrastructure for maintenance</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Simple to use</td>
<td>Low-cost providers</td>
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Reduced Costs ➔ Increased Access ➔ Improved Outcomes
Learning how to administer healthcare in space will improve healthcare on Earth

Example 1: Bone Health
Astronauts Lose Bone Density In space

<table>
<thead>
<tr>
<th>Time (months)</th>
<th>Astronauts (n=22)</th>
<th>For Comparison Women at 2 years post-menopause (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone Density</td>
<td></td>
<td></td>
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<tr>
<td>Change from pre-flight (%)</td>
<td></td>
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</tbody>
</table>

Expected Duration of Mars Mission

Outbound | On Mars | In-bound
Current Clinical Practices for Bone Surveillance and Fracture Detection Are Inappropriate in Space
New Ultrasound Technology to Monitor and Heal Bones in Space

Scanning Confocal Acoustic Navigation (SCAN)

Diagnostic mode assesses bone health in real-time
• Determines bone density
• Charts bone structural properties
• Predicts bone strength
• Detects fractures

Therapeutic mode
• Targeted via ultrasound imaging
• Stimulates bone growth
• Improves fracture healing

SCAN Can Transform Bone Clinical Care on Earth

- Safe for longitudinal and frequent surveillance
- Safe for pregnant and pediatric patients
- Portable with small energy footprint
- Appropriate for resource-limited environments
- Inexpensive to buy and easy to administer
- Can prevent bone-loss & injury; heal fractures
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Example 2: Kidney Stones
Astronauts are susceptible to kidney stones

- Increased bone breakdown leads to increased concentration of minerals in urine filtered by kidneys
- 14 astronauts developed kidney stones before or after space flight
- One symptomatic in-flight case in Russian cosmonaut
- Based on Lifetime Surveillance of Astronaut Health data, 15 to 20% of kidney stones are expected to require surgical intervention
- Symptoms are often debilitating: severe pain, dysuria, hematuria, nausea or vomiting
- Stones can lead to urine obstruction, acute renal failure, infection, and sepsis
Current Clinical Practices to Treat Kidney Stones Are Inappropriate for Space

3.1M visits Per Year

49% → PCP

51% → Urologist

70% → Surgery

30% → Fluid & watchful waiting (4-6wks)
New Ultrasound Technology to Detect and Treat Kidney Stones

- Detects and expels kidney stones using focused ultrasound energy at “diagnostic” levels
- “First-in-man” clinical trial of repositioning kidney stones ongoing

Harper JD et al., J Urol. 2013 Sep;190(3):1090-5
Technology for Space will Change Clinical Practice for Kidney Stones on Earth

3.1M visits Per Year

49% to ER

51% to PCP

Urologist 42%

Surgery

Fluid & watchful waiting (4-6wks)

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Example 3: Diagnostic Imaging
Expanding And Simplifying Ultrasound Diagnostic Protocols For Space and Earth

• Computer-based just-in-time training modules for astronauts
• Musculoskeletal, CNS, cardiovascular & abdominal scans
• Integrated into Wayne State University School of Medicine curriculum and a course administered by the American College of Surgeons
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Example 4: Brain Health
New Medical Syndrome in Astronauts is Driving Neurology Innovations

- Novel diagnostic technologies and imaging methods
- New paradigms and models for understanding brain fluid and pressure regulation
- New paradigms and models for understanding visual structures and function

Hyperopic Shifts
Up to +1.75 diopters

“Cotton wool” Spots

Choroidal Folds

Optic Disc Edema

Scotoma

Increased Optic Nerve Sheath Diameter

Globe Flattening
Normal Globe
Flat Globe

+ICP
Developing and Testing New Non-Invasive Brain and Eye Monitoring Technologies for Space and Earth

- 3-D ultrasound probe for the eye
- Brain fluid volume analyzer (blood, CSF, tissue)
- Brain oxygenation analyzer
- Intracranial pressure measurement devices
  - Two-depth transcranial Doppler
  - Cerebral cochlear fluid pressure device
  - Distortion product otoacoustic emissions
Simplifying Brain Health Monitoring for Earth

- Brain Fluid or pressure levels can increase due to stroke, brain injury (hemorrhage), infections, tumors, or other conditions
- Untreated, elevation in fluid or pressure can cause irreversible brain damage
- Early detection is key to good outcomes; conditions can deteriorate with time
- Current standard of care is MRI, CT scan, and lumbar puncture (LP) for measuring pressure on the brain
- LP has risks; CT and MRI are usually performed once due to costs; hence, many patients are not adequately monitored
- Non-invasive methods of monitoring brain health developed for astronauts will be cheaper and less risky to implement
All examples shown:

- Non-invasive
- Safe
- Easy to use
- Can be administered by lower-cost providers
- Low footprint (power, size)
- Robust

Reduced Costs ➔ Increased Access ➔ Improved Outcomes
We are looking for the next transformative health and performance technology

SMARTCAP: Space Medical And Related Technologies Commercialization Assistance Program (www.smartcap.org)

• Seed funding to small U.S.-based companies
• $100K - $250K awards
• Fulfills a need in space
• Impact on Earth
• Applications (1-2 pages) accepted year-round
• Next deadline May 8
• Awards made every quarter
• Requires a match – can be in-kind
• Investors are looking over our shoulder
Questions?

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