Behavioral Health Analogs and Team Risk

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The Future of Exploration

- 100s of Miles: International Space Station
- 1,000s of Miles: Commercial Partners
- 10,000s of Miles: Lagrangian Point L2
- 100,000s of Miles: Near-Earth Asteroid
- 10,000,000s of Miles: Mars
- 100,000,000s of Miles: Europa

Human Space Operations
Human Space Exploration
Robotic Science

www.nasa.gov/silis
Spaceflight Hazards

1. Radiation
2. Isolation/Confinement
3. Distance from Earth
4. Altered Gravity
5. Hostile/Closed Environment
Isolated, Confined, Extreme Environments (ICE)

• Isolated
  • Physical separation from civilization, community, social support
  • Communications constraints

• Confined
  • Physical habitat
    • Limited privacy, and inadequate space for work, social, and recreational activities, limited configurability and control (Kearney, 2016)
  • Social confinement
    • Crew limited to each other as the primary and often only source of social support, collegiality, and friendship

• Extreme
  • Dangerous external geophysical environment incompatible with human physiology, health, and well-being
    • Lack of or toxic atmosphere, temps, altitude, non-24 h light–dark cycles, wildlife threats (e.g., predatory animals, microorganisms, toxins), reduced gravity, and risk of exposure to radiation and other low-frequency/high-impact phenomena (e.g., solar flares, rough seas, dust storms, blizzards, high winds, and volcanism)
ICE Operational Environment Context

- Dynamic Closed System
  - Everything can affect everything
  - Beyond behavioral risks
  - Passage of time matters
Individual and Team Behavioral Health Risks

• Behavioral Emergencies
• Diagnosable Disorders
• Behavioral Signs & Symptoms
• Cognitive Decrements
Behavioral Health Analogs
A Word on Analogs

• Analog, Model, Simulation
  • Analog $\approx$ model
    • Analogous
      • Share some fundamental defining feature(s) of the target system
      • “Ship in a bottle”
  • Underestimation vs Overestimation of Risk

• What is not included, what is simulated, and what is real
Analog Research

• Risk Characterization
  • Nature of individual and team behavioral health and performance adaptations to ICE conditions
  • Risk interactions

• Test Countermeasures
  • Opportunity for control, experimental design, sample size

https://www.nasa.gov/analogs
Analog Research

• Antarctica: McMurdo Station, Concordia Station, Neumayer III Station
Analog Research

• Isolated, Confined, Controlled (ICC)
  • HERA, NEK/SIRIUS, HI-SEAS
Individual Behavioral Health

- Behavioral Emergencies

<table>
<thead>
<tr>
<th>Prevalence</th>
<th>Risk</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 attack with ice axe</td>
<td>Violence/homicidity</td>
<td>Vostok Station (axe) - 1959</td>
</tr>
<tr>
<td>2 arson (1 intoxicated, desire to be sent home)</td>
<td></td>
<td>McMurdoo (intox. arson) - 1981</td>
</tr>
<tr>
<td>1 attack with hammer</td>
<td></td>
<td>Almirante Brown Station (arson) - 1984</td>
</tr>
<tr>
<td>1 stabbing</td>
<td></td>
<td>McMurdoo (hammer) - 1996</td>
</tr>
<tr>
<td>1/10 ‡</td>
<td>Depression (needing evacuation)‡</td>
<td>Polish Polar Station, Svalbard (Temp et al., 2020)</td>
</tr>
<tr>
<td>3/12 crew evacuated</td>
<td>‘Severe Depression’ GHQ elevations</td>
<td>A British station (Bell &amp; Garthwaite, 1987)</td>
</tr>
<tr>
<td>1/36 crew</td>
<td>Suicidal ideation</td>
<td>Palmer Station (summer) (Pattarini et al., 2016)</td>
</tr>
</tbody>
</table>

*No work performance deficit despite clear distress/mood despondency
Individual Behavioral Health

- Diagnosable Disorders

<table>
<thead>
<tr>
<th>Prevalence</th>
<th>Risk</th>
<th>Population</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>5.2% incidence</td>
<td>Any DSM-IV D/o (mood = 30.2% of d/o; adjustment = 27.9% of d/o, sleep-related = 20.9% of d/o; personality = 11.6% of d/o; substance use = 9.3% of d/o)</td>
<td>Antarctic crew (with psych selection)</td>
<td>Palinkas et al., 2004</td>
</tr>
<tr>
<td>~5% incidence</td>
<td>Any ICD-9 D/o</td>
<td>Antarctic crew (no psych selection)</td>
<td>Norman, 1991</td>
</tr>
</tbody>
</table>
## Individual Behavioral Health

- **Behavioral Signs & Symptoms**

<table>
<thead>
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<th>Prevalence</th>
<th>Risk</th>
<th>Population</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.66% of clinic consults</td>
<td>Mix of insomnia, anxiety, &amp; depression</td>
<td>Indian Antarctic Station</td>
<td>Bhati et al., 2013</td>
</tr>
<tr>
<td>11.5% of winterover crew</td>
<td>Lethargy &amp; loss of appetite</td>
<td>Indian Antarctic Station</td>
<td>Bhati &amp; Pal, 2012</td>
</tr>
<tr>
<td>7% of 134 clinic visits</td>
<td>“Psych related” symptoms</td>
<td>Palmer Station Antarctica</td>
<td>Pattarini et al., 2016</td>
</tr>
<tr>
<td>62.1% self-reported depression symptoms</td>
<td>Depression symptoms/Winter-Over Syndrome</td>
<td>McMurdo Station, 1989 winter season</td>
<td>Palinkas, 1992</td>
</tr>
<tr>
<td>47.6% more irritable</td>
<td>Irritable/Winter-Over Syndrome</td>
<td>McMurdo Station, 1989 winter season</td>
<td>Palinkas, 1992</td>
</tr>
<tr>
<td>N=30</td>
<td>Net decreased engagement in coping activities over course of the mission. But small decrement.</td>
<td>Submariners, 23-day patrol</td>
<td>Van Wijk, 2018</td>
</tr>
</tbody>
</table>
Individual Behavioral Health

- Individual differences in cumulative depressive symptoms and mood over 520-day mission (Basner et al., 2014)
Individual Behavioral Health

- Decrease in positive affect ratio over 8-month HI-SEAS mission (Engler et al., 2019)
Cognitive Decrements

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<tr>
<th>Prevalence</th>
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<th>Population</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>51.5 %</td>
<td>Reported difficulty with concentration or memory</td>
<td>McMurdo, 1989 winter season</td>
<td>(Palinkas, 1992)</td>
</tr>
<tr>
<td>N=1</td>
<td>Acute attention &amp; memory deficit (context: hypoxic environment, inadequate nutrition, high physical workload, psychosocial stress)</td>
<td>Biosphere 2</td>
<td>(Lassinger et al., 2004)</td>
</tr>
</tbody>
</table>
Improved response speed and reduced lapses in vigilant attention after mid-mission Mars orbit and surface operations (Basner et al., 2013)
Team Behavioral Health

- Dozens of reported incidents of team process and conflict problems in long-duration spaceflight analogs, a few are listed below
  - International Biomedical Expedition to the Antarctic
    - Reports of significant sub-grouping, conflicts, and intra-crew competition
    - One crewmember evacuated due to psychological issues, potentially related to interpersonal stressors
  - SIRIUS Arctic patrols
    - Reports of significant interpersonal conflicts between patrol members, up to and including cutting off interaction/communication between patrol members
  - 135d Mir simulation – Moscow
    - Evidence of crew breakdown over time, development of subgroups, intra-group tension
    - Self-reported cohesion significantly declined over time
  - South Pole Station winter-overs
    - Crews with significant sub-grouping reported higher levels of depression, anxiety, anger, and fatigue than those that identified as a single cohesive group

Kanas, 2004; Natani, & Shurley, 1974; Palinkas, Gunderson, Johnson, & Holland, 2000; Sandal, 2004
Team Behavioral Health

NEK Long-Duration Chamber Studies

• Mars500 105d simulation – Moscow
  • Reported interpersonal differences increased over time
  • Reported interpersonal tension within the crew attributed to these differences increased over time

• Mars500 520d simulation – Moscow
  • Based on reports of social interaction, one crewmember became socially isolated from the rest of the crew over the course of the mission
  • Conflicts between crew and ground reported throughout mission, increasing up to and during ‘surface’ operations
  • Intra-crew conflicts reported throughout mission, increasing later in the mission
  • Crew/ground conflict reported 5x more often than intra-crew conflict

Basner et al., 2014; Sandal et al., 2011; Vinokhodova, et al., 2012
Summary

• Individual Behavioral Health
  • Emergencies rate, but high impact
  • Dx low prevalence, but
  • Sub-clinical alterations in neurobehavioral functioning

• Team Behavioral Health
  • No Dx per se
  • Social functioning major overlap with indiv behav health
  • Morale, cohesion, team/social dynamics, conflict management

• Largely positive, achievement, growth opportunity
Challenges for Behavioral Health Analogs

• **Protocol Integration**
  - Quality of evidence relates to quality of crew experience
  - Multidisciplinary, multi-level

• **Meaningful Work**
  - Increasing fidelity of model
  - Moon as analog for Mars

• **There is no analog for time!**
  - Long-duration missions
  - Time is critical variable for individual and team behavioral health risk
Look Ahead for Behavioral Health Analogs

• HERA
  • Upcoming campaigns focus on human-computer interaction and integration

• NEK/SIRIUS
  • 4-month mission completed, preparing for 8-month, possible 12-month

• Ongoing Continuing work in Antarctic stations
ICE Context

• Dynamic Closed System
  • Everything can affect everything
  • Passage of time matters
  • Beyond behavioral risks

• Multiple interacting pathways to increase risk = multiple interacting pathways to reduce risk!
Ongoing Work on Behavioral Health Countermeasures

- Identification and recommendations for essential selection and composition factors for long-duration missions
- Development and validation of pre-mission and in-mission training to support individual and team behavioral health
- Development and validation of tools for monitoring and predicting individual and team behavioral health
- Development and validation of in-mission countermeasures to maintain and repair individual and team behavioral health
  - Cross-cutting

https://humanresearchroadmap.nasa.gov/Tasks/
Onward and Upward!

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