



Operational Impact of an Onboard Pharmacy: Mission Impact and Risk Considerations

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Goals



- ❖ Discuss the operational impacts of the onboard pharmacy
- ❖ Discuss risks associated with the inability to supply a safe, robust, and comprehensive formulary for long-duration spaceflight outside of low-Earth orbit (LEO)
- ❖ Discuss implications of these risks
- ❖ Discuss potential mitigation strategies to address this risk



Outline



- ❖ Introduction
- ❖ Concerns/Risks
- ❖ Implications
- ❖ Potential Solutions



Introduction



- ❖ Pharmaceutical intervention is essential component of risk management for astronaut healthcare during exploration spaceflight
- ❖ Historically, medication use has not been comprehensively monitored (largely due to crew time constraints)
- ❖ Currently, certain medications can be used without prior consultation with a flight surgeon (e.g. OTCs for headache or congestion)
- ❖ Such use may be reported during weekly Private Medical Conferences (PMCs), but there is currently no requirement to do so
- ❖ However, due to delayed reporting, information such as indication, dose, timing, or side effects may not be reported or recorded



Introduction



- ❖ Medication use reporting has improved over time (as discussed by previous presenter)
- ❖ Common complaints: headache, congestion, sleep disturbance, space motion sickness



Introduction



- ❖ With stricter reporting, the significance of an on-board pharmacy becomes clear
- ❖ NASA's Human Research Roadmap (HRR) identifies medication use as a potential countermeasure for prevention or management of several conditions
 - Examples include:
 - Potassium citrate for nephrolithiasis prophylaxis
 - Pain medication for EVA-induced pain or injuries
 - Antidepressants or antipsychotics for adverse cognitive or behavioral conditions and psychiatric disorders
 - Bisphosphonates for bone fracture due to spaceflight-induced changes to bone
- ❖ In analysis of medical capabilities needed for a Mars transit mission, NASA's Exploration Medical Capability (ExMC) element preliminarily identified onboard pharmacy as the largest single component of a complete medical system (>25% of all medical interventions)



Concerns/Risks



❖ Anecdotal evidence that medications may be less efficacious in spaceflight

- Space Shuttle – Putcha (1999)
 - 13 different medications “not effective” or “mildly effective”
- Space Shuttle/ISS – Barger (2014)
 - Sleep medication – 17-19% of cases required second dose

❖ Medication stability

- 87% of medications flown on ISS have shelf lives <24 months
- Many may be repackaged to save weight/volume, especially for exploration missions
- Radiation can play a role in degradation of API (active pharmaceutical ingredient)
- Significant limitation for exploration-class missions



Concerns/Risks



- ❖ PK/PD may be altered
 - Pharmacokinetics (body effects on medications)
 - Pharmacodynamics (medication effects on body)
- ❖ Altered microbial growth and antimicrobial susceptibility
- ❖ Inability to evacuate to Earth quickly



Implications



❖ Bottom Line:

- These concerns/risks may lead to a medication being unavailable when needed without the ability to resupply or evacuate the patient
- Without a safe and comprehensive on-board pharmacy, may not be able to fully address certain medical issues in an astronaut during an exploration-class mission

❖ If unable to fully treat medical condition:

- Potential performance decrements that could impact successful completion of science and/or mission
- Additional time/resources in space and on the ground devoted to a problem that may have been rectified with appropriate medication
- Use of sub-optimal medication to manage condition may mean that this medication is unavailable to treat another better-suited issue later in the mission



Potential Solutions



- ❖ Goal: Supply a safe, robust, and comprehensive pharmacy for long-duration spaceflight outside of LEO
- ❖ Standardized documentation or medication tracking to provide better physician awareness and allow for more accurate inventory management
- ❖ Better medical condition/risk prediction in order to appropriately weigh trades when optimizing the on-board exploration medical system
- ❖ Investigation/research into:
 - Stability and/or shelf-life extension
 - Ground-based radiation exposure
 - PK/PD



Thank you



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