

Assessing Crew Medical Officer Preparedness for International Space Station Missions

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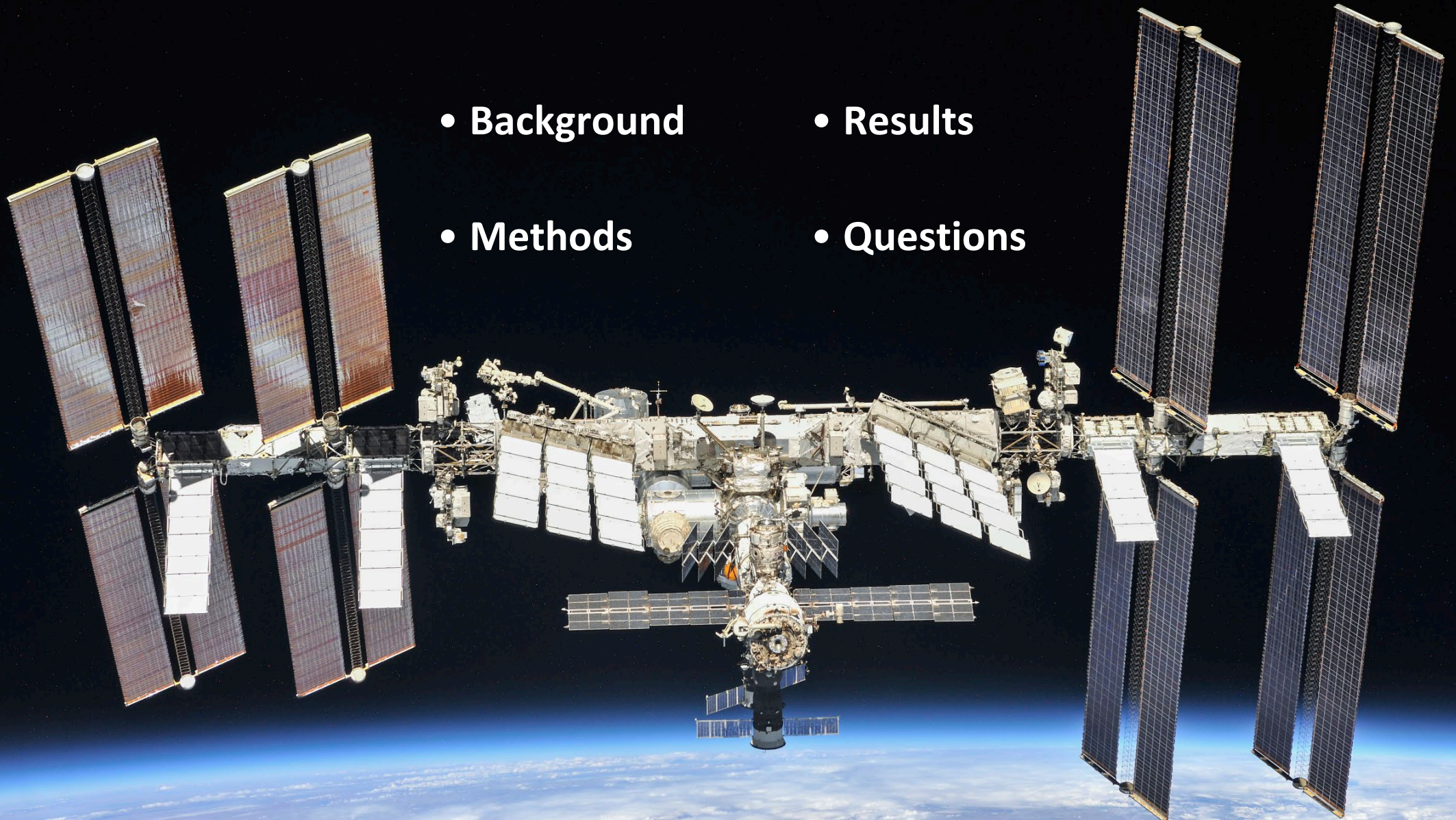
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- Crew Medical Officers (CMOs) provide medical support in-flight and on-station
- They do not have to have prior medical training, though it is preferred
- They receive additional training covering med kit orientation, performance of vitals, otoscope use, urinary catheter and IV insertion, medication administration (IV, IM, SQ), and skin laceration repair
- The ISS CMO role is empowered by continuous ground support and rapid evacuation capabilities



- There has never been a formal retrospective evaluation of CMO preparedness and training in the ISS era
- Artemis/Exploration class CMO preparedness will draw on ISS training
- As post-flight debriefs are short, this study aimed to formally interview former CMOs regarding their **pre-flight CMO training, in-flight utilization of these skills and medical resourcing**, and to conjecture about **future CMO training and resource needs** for LEO, Artemis, and long-duration exploration-class missions

- Coordinated with Astronaut Office to solicit voluntary participation via email
- Interviews with former American crew designated as CMO who flew at least 1 ISS mission from 2010-2022* after CMO training
- Aim for 20 participants, split 50% physician CMO and 50% non-physician CMO
- Semi-structured interview based on interview tool
 - 20 questions: background training, CMO experience, future mission considerations, interview QI

- Microsoft Teams interviews, recorded, transcribed, stored on encrypted NASA systems
- Transcriptions de-identified and de-attributable
- Qualitative thematic analysis by two independent coders using NVivo Software
- Emergent themes compiled and organized into this report
- IRB granted Not-Human Subjects Research (NHSR) 4/2022 as internal quality improvement
 - Formal IRB and re-consenting of subjects obtained 12/2023

STUDY PARTICIPANTS TO DATE



- **10 subjects have completed the interview process**
 - 5 DOD, 5 Civilian
- **4 physicians**
 - 2 Emergency Medicine
 - 2 Internal Medicine
- **6 non-physicians**
 - Previously had either BLS/first aid or DOD standard battlefield injury/triage training
- **Phase 1 analysis: n=5**
 - 3 DOD, 2 civilian
 - 2/5 physician CMOs (both internal medicine)
- **Phase 2 analysis: n=5**
 - 2 DOD, 3 civilian
 - 2/5 physician CMOs (both emergency medicine)

We will now discuss your specific experiences as a Crew Medical Officer

Concerning future missions

The following questions focus on tradeoffs in training given constraints on available training time

10. Were you missing any resources (medical hardware, medications, onboard references, access to flight surgeon/ground specialists, etc.) that you would recommend **are** absolutely needed for **ISS**

If time allows – If interview has already run for 45 minutes, then ask crewmember their preference and do this section or skip to Part IV.

- 11
14. Were you confident in your training and problem management for day-to-day, minor, medical issues encountered as CMO during your mission?
- 12
15. Did you feel prepared for high risk but low likelihood events like major injuries, punctured lungs, heart attacks, etc.?
16. Would you want additional targeted just-in-time training in “improvised/expedient” austere medicine?
- 13
17. Should clinical time in urgent care or medical clinics (“field-training”) be mandated pre-flight for a CMO?
18. Can you describe memorable times when you used your CMO training aboard ISS?
- a. Were there specific clinical conditions you witnessed or treated in-flight?

RESULTS – ROLE OF CMO – COMMON THEMES



- **CMO is a relatively minor role on ISS that takes up little task time**
 - “It was really 1% or less. We didn't have any big medical issues.”
- **First responder, triaging medical problems, performing first aid, and knowing when to call ground**
 - “I would define that role as being ready to follow the instructions from the Doctors, so understanding when you need to get help, and I think that's a big thing about our training is just is recognizing that you get really, really good customer support. So, you have to have familiarity with the skills you got to do, not any diagnostic skills ”
- **Involved in periodic routine health checks and onboard medication administration**
- **Assist with simple procedures (e.g., phlebotomy, minor head injuries)**
- **Role/dynamic changes when a physician is onboard, then it's supporting them**
 - Sometimes an astronaut physician was part of the crew but NOT the formal CMO for the mission
- **Responsibility scales up in an emergency scenario**
 - “someone bangs her head, has a small cut ... and all the way up to getting someone home, right? If they need to get home in a real critical emergency.”



- **CMO confidence from training varies, tends to be better with prior experience**
 - “I don't know how much trust the other crewmembers had in our [CMO] capabilities”
 - “I think it's different also when you are a physician; when you're a physician, people freely come up to you.”
 - “[I didn't have] the number of reps that I would have liked to have. I think because we had people with experience, I think I was confident that we could definitely piece it together, but I was not as prepared.”
 - “I don't know if you could actually, you know, if you don't have a medical background, if you ever actually feel totally prepared for [acute critical illness].”
- **Comfort decreased with acuity of illness and need for adaptation**
 - “I probably would have not wanted to really stray too far from the procedure without having to go step by step and really making sure I wasn't missing something... What I was less confident about is for those intervening things or maybe a complication”
- **Field Medical Training improved confidence**

RESULTS – WHO SHOULD BE TRAINED – COMMON THEMES



- **Everyone onboard should have the same foundational “CMO” knowledge**
 - “Nobody’s saying, ‘Oh, you’re the CMO, you’ve got to handle this...’ We’re just helping each other out and so you need that kind of common level of training... there’s this minimum bar that everybody needs to train to.”
 - “I thought it was normal... everyone having that training... It seems like a pretty basic skillset... so it seemed like you would want everyone to do that.”
 - “You might have someone who's responsible for making the decision, but everyone having a baseline of this kind of [medical knowledge]”
- **Having multiple CMOs improves safety by reducing reliance on one individual**
 - “We want to make sure we get two CMOs.”
 - Multiple conversations were held regarding if the CMO is the one who gets sick
- **Physician CMOs rely more heavily on prior knowledge**
 - “I never looked at the checklist for chest pain because I’d be going down my own checklist. That checklist is for an untrained person.”
 - “Just like CPR into Defibrillation, or doing an IO injection that, you know, that kind of stuff. I was pretty confident about that procedure, like how to do it. I think if anything I was concerned I’d probably be pretty slow doing it”



- **Highly desired but not a requirement for CMO to be physician in LEO**
 - “I don't think it's a requirement to have a physician fulfill that role if we're focused on LEO.”
 - “Highly desired, but I would probably stop short of saying required for assignment”
 - “But even then, having a physician onboard is not going to change things because we’re going to need have a ground tied in and providing us the kind of the direction to stabilize whoever needs to be stabilized.”
- **Highly desired but not a requirement for brief Lunar missions**
 - “...not as big of a deal because I can still kind of have a real time conversation with somebody on the ground.”
- **Probably best to have a physician onboard for exploration class missions**
 - “[For exploration class missions], you'd have to have quite a bit of training, that a physician would already possess, to give to a non-physician crew member... I think the longer mission, the benefit of having a physician onboard increases linearly, if not exponentially... it’s that number of problems that could arise, become a greater probability.”



- **Field medical training (FMT)**

- “The more [field] training, the better.”
- “In a perfect world, the answer is more FMT... I was confident [with] basic health checks. I was confident [with] the defibrillator, but the in between stuff, like having to actually do stitches... that sort of medium level wounds... I think that’s where I would say my skills gap was.”

- **Improvisation with limited resources**

- “Can you run a code? Yes you can. For a little bit of time. You just don’t have the sheer amount of consumables... [exploration class missions] force you to think very differently.”

- **Baseline training pre-assignment would likely be best**



- **Ultrasound capabilities are important**

- “I would highly recommend ultrasound.”
- “At least like a pocket ultrasound.”

- **Burns/Wound care – from initial evaluation/treatment through chronic stages of healing**

- “Training on treating burns would also be very valuable. You know, that was one thing that we didn’t cover, and I didn’t think about it up there. But if you have a burn it can be bad.”
- “For big burns and electrical injuries and smashed hands and fingers and toes. That type of thing is more likely what they're gonna see.”



- **Lacerations are common, suture course is too brief, need pre-flight refresher**
 - “the suturing course was pretty quick... I wasn't all that confident or competent in suturing at the time.”
 - “Simple lacerations are not uncommon on-station. I think we just used butterfly bandages”
- **Injections are common: IM, SQ**
 - “Most of what [injections] I gave were Phenergan injections to crew... for space adaptation syndrome”
- **Communication/Behavioral health skills are important**
 - “We don't receive formal training on how to do good interviews in that manner, how to approach people, how to phrase things. So that would be a thing I would change for much longer duration missions.”



- **CMO training currently doesn't teach diagnostic skills, but some triage ability**
 - “[CMO training] can't teach you diagnosis. They teach you how to follow a checklist, and when to call down in the ground, but they can't teach you clinical skills, obviously, or intuition.”
- **Skills learned on Earth take a little longer to perform well in microgravity**
 - “Having things floating around and trying to manage it and, changing tubes by myself was challenging.”
- **Training should include common space adaptation symptoms**
 - “so that they can know when it's like, ‘Yeah, this is spacelight. You're gonna have symptoms. You're gonna feel stuffy’ versus when it, ‘Oh no, this could be some sinusitis, like going in a bad place.’ So that everybody can kind of monitor themselves.”



- **Important to gain procedural experience on variety of patients**

- “I can get really good at drawing my own blood... but somebody else's arm where you encounter some difficulty... getting the repetitions and the variation on people is good.”

- **Sometimes months between CMO training and flight, refreshers pre-flight are valuable**

- “Maybe actual practical hands-on-doing would solve some of that or just a refresher closer to flight. Which I know everyone says. Wow. All topics. Like it would be great to do this closer to flight, but then when you stack those all up, it's six months before flight”

- **Desire to have skill performance evaluations**

- “At NASA, we get kind of softballed [evaluations]. We really don't get, “you are going to fail if you don't do this thing correctly.” It's more like, “Hey, here's some here's some helpful hints on how you do it next time.” You never feel like you are at risk of being told you gotta do this whole event again because you didn't succeed at it. [For the Russians] there's an oral exam—a system—you stand in front of a bunch of very critical people that will tell you, “that was weak, and you need to do this test again.”



- **Should have more of a temporizing, wilderness medicine mindset**
 - “and less about using the capsule as an ambulance that's gonna get someone to critical care in a few hours”
- **Medical providers should be more like physician extenders, with greater emphasis on information gathering, and competency in nursing and wound care skills**
- **Hands-on training is critical**
 - “And then that in combination with [field medical training in a trauma center.] just so many opportunities to just get used to the blood and the guts and chance to sew things up, and particularly hands.”
- **Need to accept certain degree of risk based on mission profile**
 - “Without trying to be morbid, but I mean, you know that someone's gonna die in space one day. They do on Earth, they do on every on Earth, every day. Sometimes in the best hospitals in the world”



- **Onboard protocols can offset clinical experience**
 - “I think that's where I think the having the reference material or the just-in-time training videos, augmented reality, whatever onboard is really gonna be essential.”
 - “I didn't feel like I had enough of an ability to go on my own without having to pretty much follow each procedure step by step.”
- **In-flight / Just-In-Time training would be helpful (tends to be tied to payloads though)**
 - “A series of videos like short, like just-in-time training videos on [injections, drawing medicines in microgravity].”
 - “...perhaps augmented reality or just videos”
- **Valuable to have crewmember pre-flight imaging available for comparison on-station**
 - “I think it would be super beneficial to have access to baseline imagery of my crewmates. You know, we do enough scans on the ground, so I’m like, “If they are going to look at all my organs through ultrasound every year, and those images exist... so if you were trying to look for an abnormality while I was onboard, it'd be nice to have a referenced set of, ‘Well, here's what the crew member looked like before they launched.’”



- **General equipment**

- Overall happy with the medical supplies scoped to the ISS
- Otoscope and stethoscopes are probably necessary, point-of-care ultrasound would likely be valuable
- Dermabond and steri-strips would be really helpful
- Crew sometimes bypass CMO to grab familiar OTCs
- Kit should be “more robust” for Lunar missions

- **Rarely used meds/devices should still be included**

- “Some of the antibiotics, antipsychotics... We carry them just in case, but they weren't needed, but I wouldn't recommend that they be deleted from a medical kit.”
- “I don't think you need a full suite of antibiotics. I think you can get away with a lot. We've got a lot of very good multipurpose antibiotics out there that can serve a lot of different roles.”



• ACLS

- Lunar CPR will look closer to microgravity CPR
 - “The force holding you in place is only 1/6th of what it normally would be.”
- Airway management likely still valuable, but a ventilator is not needed
 - “Airway maintenance is probably still a pretty important thing.”
 - “...worst case scenario, right? Just bag somebody.”
- AED has never been used but worth keeping
 - “I could see keeping an AED just for monitoring and you know, but again keeping the whole suite of ACLS, that's a much bigger discussion the program's gonna have to have. ”
 - “[One of] the most useful trainings was going to when simulations of somebody having a heart attack and so having some familiarity with that.”
- Choosing to include ACLS capability should include a plan for return to definitive care
 - “who are we serving by even having that capability up there, so without a complete thinking through and connecting the entire chain all the way back to the definitive medical care”



- **Space Adaptation**

- “Space adaptation period is when most of the medical problems occurred.”
- “[For space adaptation], just giving them [the crew] personal tips about how we adapted. No need for CMO training on it... the experience of having gone through it yourself is enough [to teach about it].”

- **Urinary Retention**

- “I felt ill prepared if we would have had to do a female catheterization.”
- “Urinary retention became quite uncomfortable. Eventually they did urinate, but we carry catheters just in case something like that happens”

- **MSK Complaints**

- “The therapy exercises, a big rubber band, towels, just holding stretches... I think is really important”

- **Minor hand and finger injuries are common, basic superficial wound care**

- **Dermatitis is very common**

- “the dermatitis like that can make you miserable”

- **Eye irritants (foreign bodies, tabasco) are very common, eye wash ability is necessary**



- **All crew should have some baseline medical skills**
- **Dental training and equipment could probably be removed**
 - “If I'm injecting somebody trying to numb their jaw so I can pull a tooth, it's a bad day... and it would be a pretty extreme situation where we're kind of down that path.”
- **Need decontamination for Lunar dust**
 - “It's almost not so much the medical realm, but like the decontamination realm of trying to remove a lot of that dust.”
 - “We don't really understand what the effects of Lunar dust [for Artemis] are.”
- **Eye care capabilities are important**
 - “I do think some capability to eyewash, even if it's just a little squeeze bottle, just in case somebody is cleaning the suit, has some regolith on their fingers and puts in their eyes.”



- **Focus should be on treatment capabilities more than research (e.g., no OCT)**
- **Comm delays will likely be manageable and probably not all that different from ISS**
- **Shorter missions should focus on stabilizing medical issues**
 - “You know, with the mentality of like 7 to 10 days, you can just be just... be in more of a “suck it up” mindset of like if you can at least ease the pain, then you can deal with the other stuff until you get back”

- Ten former CMOs were interviewed, and common themes extracted by two independent analysts.
- CMO is a first responder who does first aid, and triages the decision to call to the ground
- Redundancy of CMOs training is desired, and a physician is desired but not needed until Mars
- Field medical training was highly praised and more experience strongly recommended
- Should know ultrasound skills, wound care (initial injury through healing), injections, behavioral interview skills, space adaptation, urinary retention, foreign body in eye, and triaging MSK pains/strains
- Consider performance-based standards for passing training

- Preflight refreshers preferred if time would allow
- Resources supplement clinical inexperience to an extent, video references would be helpful
- Onboard radiographic (sonographic) baseline for each crew would be useful
- Could consider removal of dental equipment from med kit; keep antibiotics/antipsychotics
- May not need full ACLS capabilities, however BLS and AED desired
- May not need ventilator, but some airway supplies and bag-valve mask still desired
- Artemis: Lunar dust is going to be an issue; treatment should focus on stabilizing people for nominal return

Questions?