

# The Effect of Mission Duration on Predicted Medical Risk and Medical System Design Considerations for an Extended Duration Lunar Mission

Human Research Program

Exploration Medical Capability Element

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“Expanding the Boundaries of Space Medicine and Technology”

*94<sup>th</sup> Annual Scientific Meeting, Aerospace Medical Association,  
Chicago, IL, May 6-9, 2024*



# Disclosure Information

*94th Annual Scientific Meeting*

*Arian Anderson, MD*

I have no financial relationships to disclose.

I will not discuss off-label use and/or investigational use in my presentation

OR (select one – delete the other)

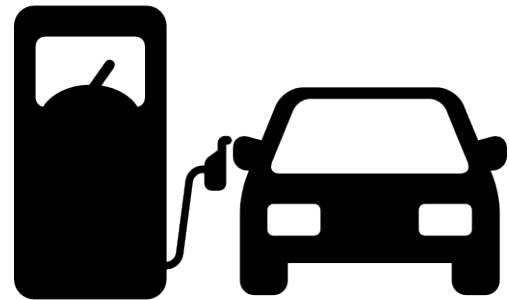
I will discuss the following off-label use and/or investigational use in my presentation:

- **IMPACT**
- **Background**
- **Approach**
- **Output**
- **Challenges & Limitations**
- **Lessons Learned**

# What is IMPACT?

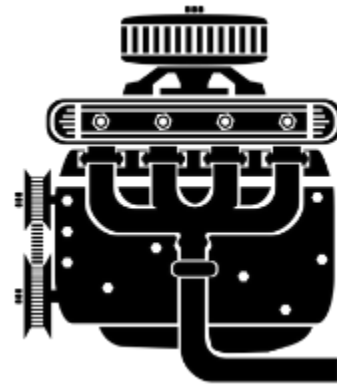
## Informing **M**ission **P**lanning via **A**nalysis of **C**omplex **T**radespaces

Updated  
Evidence Base



+

Computational  
Engine (MEDPRAT)



=



- Exploration-focused
- Next evolution of Integrated Medical Model (IMM)
- Operational in 2024



Capabilities/Resources



Medical system:

- Mass
- Volume
- Power

Risk Metrics

- Loss of Crew Life
- Medical Evacuation
- Task time affected

- 10 days on Orion outbound to NHRO insertion and Gateway rendezvous
- 10 days on Gateway in NRHO
- 6 hours HLS to Lunar surface
- 168d (24w) on Lunar surface in lunar habitat
  - 2 Lunar surface EVAs of 2 crew per week (48 EVAs with 2 crew > 24 per person per mission and total of 96 person/EVAs)
    - Corresponding habitat dust exposures for crew who did not go on EVAs still present for each
  - Prolonged expeditions in pressurized rover
- Return on HLS to Gateway
- 10 days on Gateway in NHRO
- 5 days inbound to Earth on Orion

- **Total: 209d Lunar Mission**

- **How does Mission Duration affect risk?**
- **How does number of EVAs affect risk?**
- **How do Medical System requirements change with longer duration?**
  - What resources have higher value over time?
  - What resources have higher value on short missions?

- **10 days on Orion outbound Gateway**
  - **10 days on Gateway in NRHO**
  - **6 hours HLS to Lunar surface**



• **7d on Lunar Surface w/ 4 EVAs**

• **168d on Lunar Surface w/ 48 EVAs**

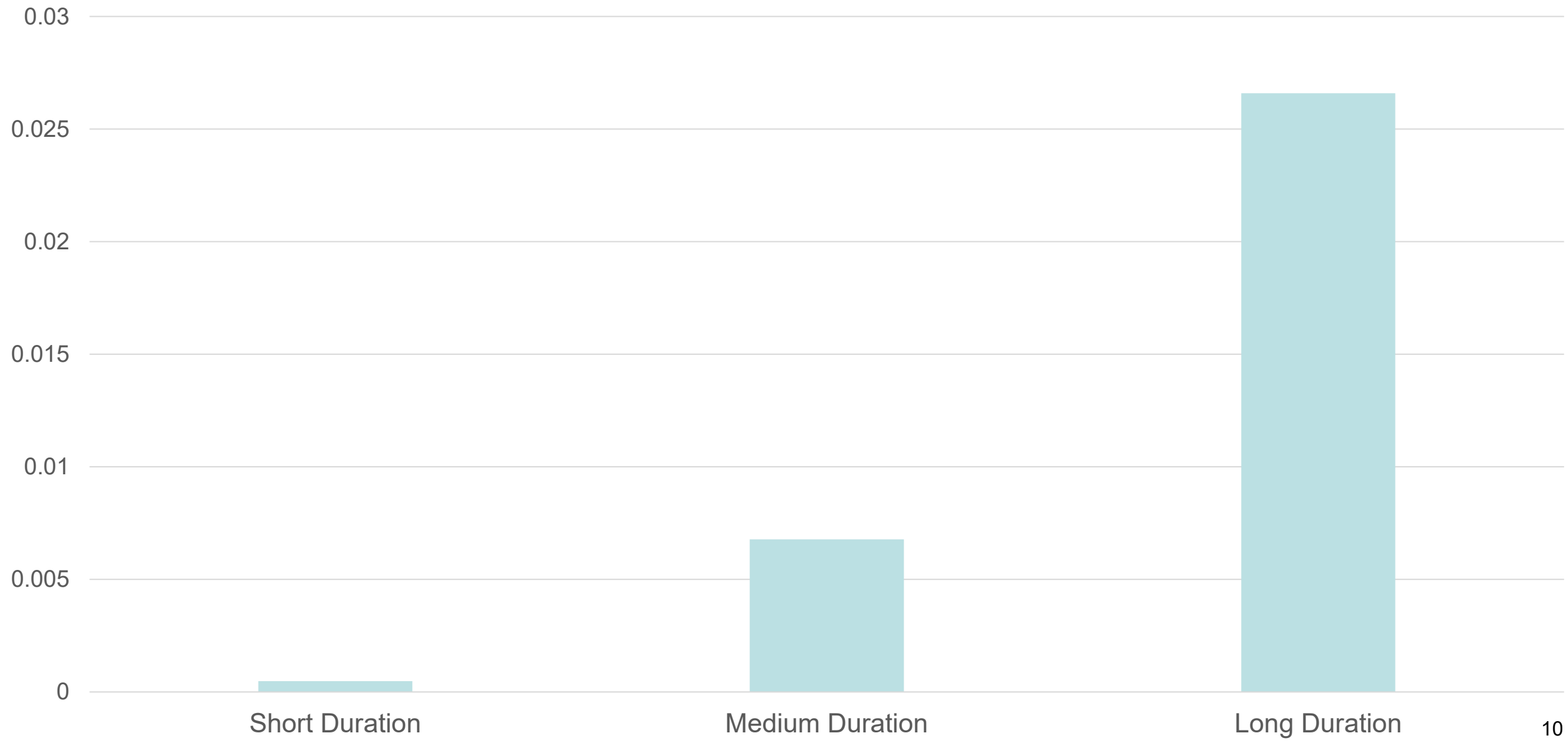
• **505d on Lunar Surface w/ 288 EVAs**

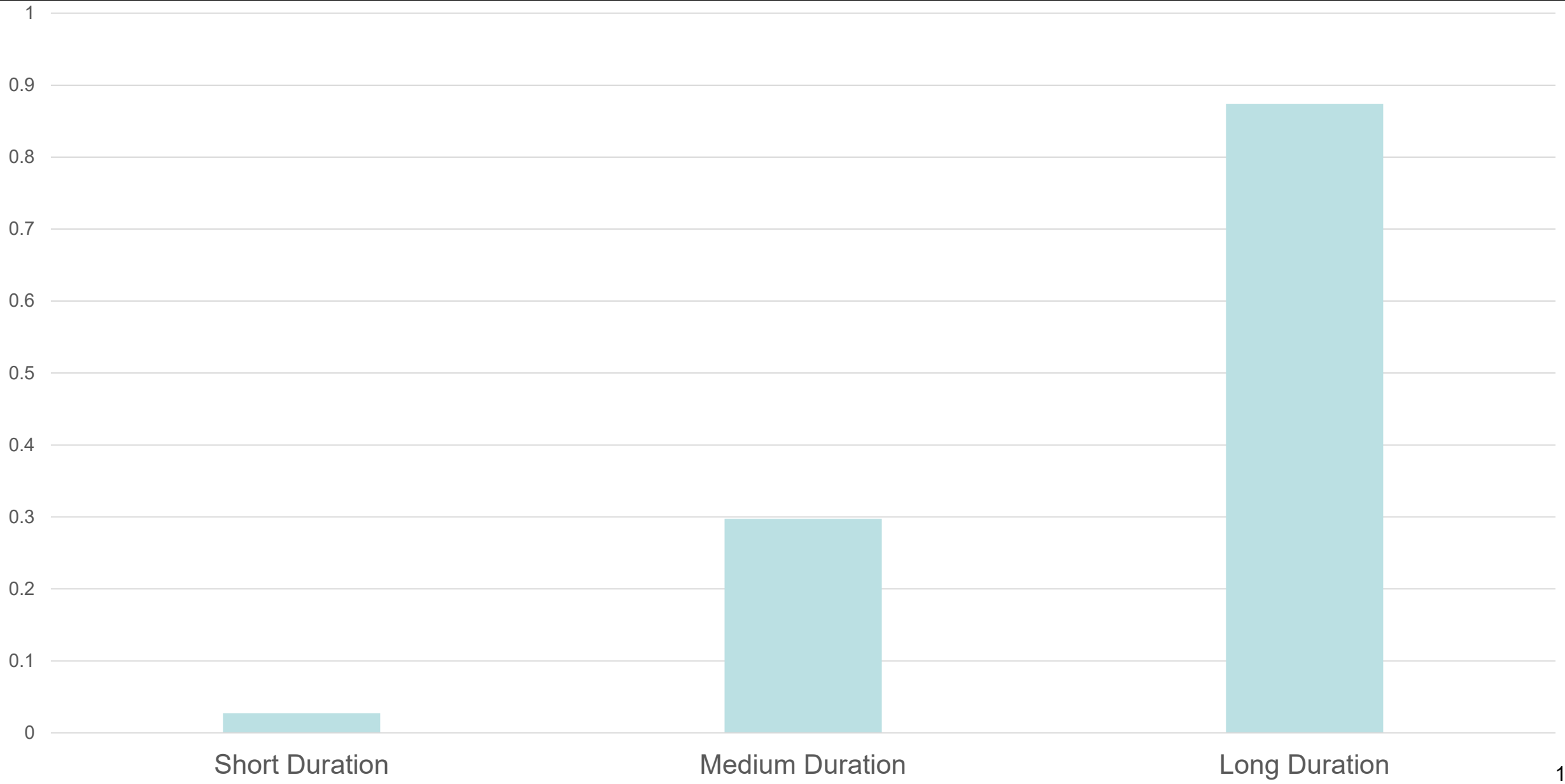


- **Return on HLS to Gateway**
- **10 days on Gateway in NRHO**
- **5 days on Orion inbound Earth**



- **4 Crewmembers**
  - 2F and 2M
- **One crewmember with dental crowns**
- **Medical system mass:50kg**
- **Medical system volume:150L**





# TTL Risk

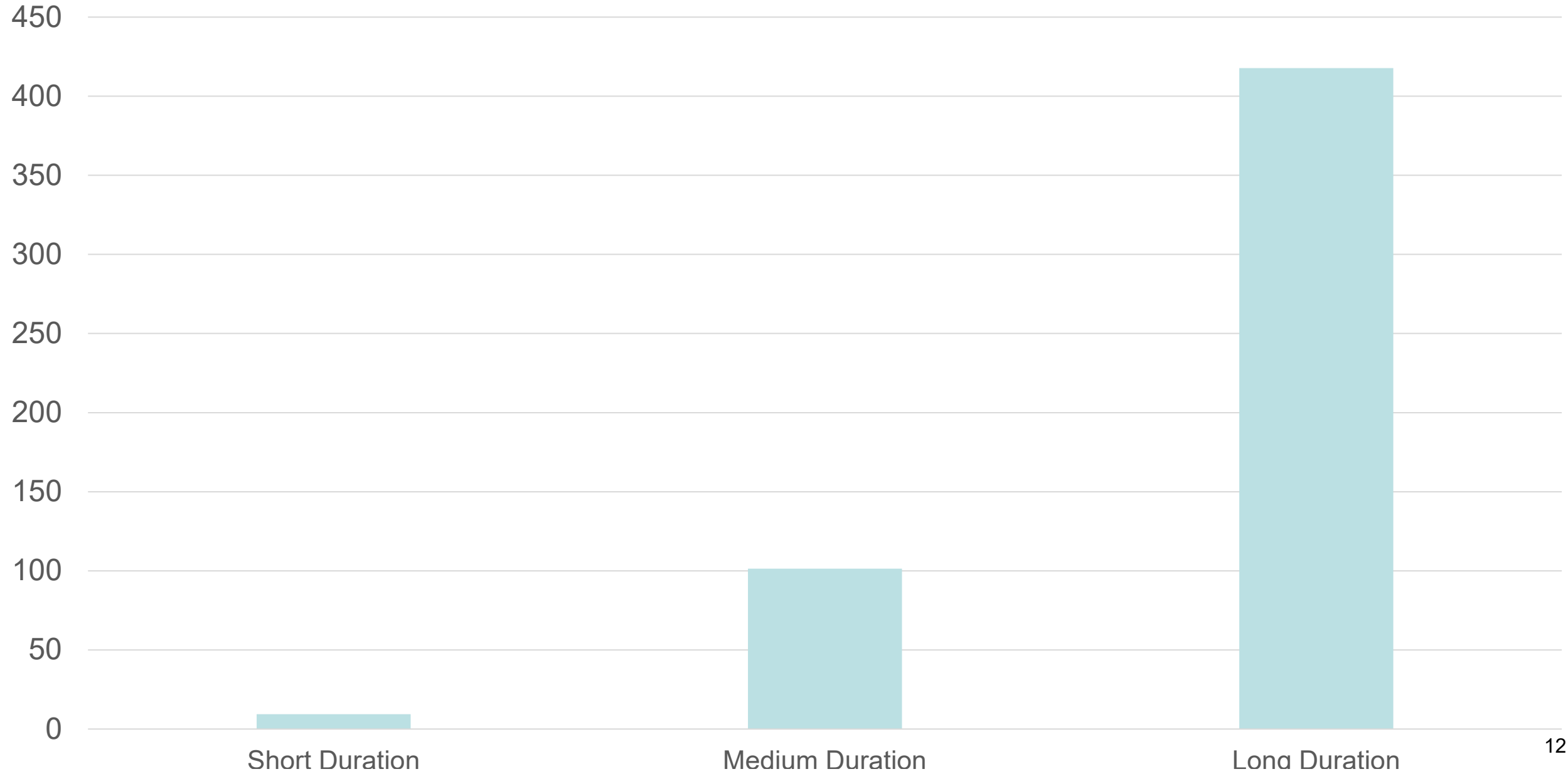
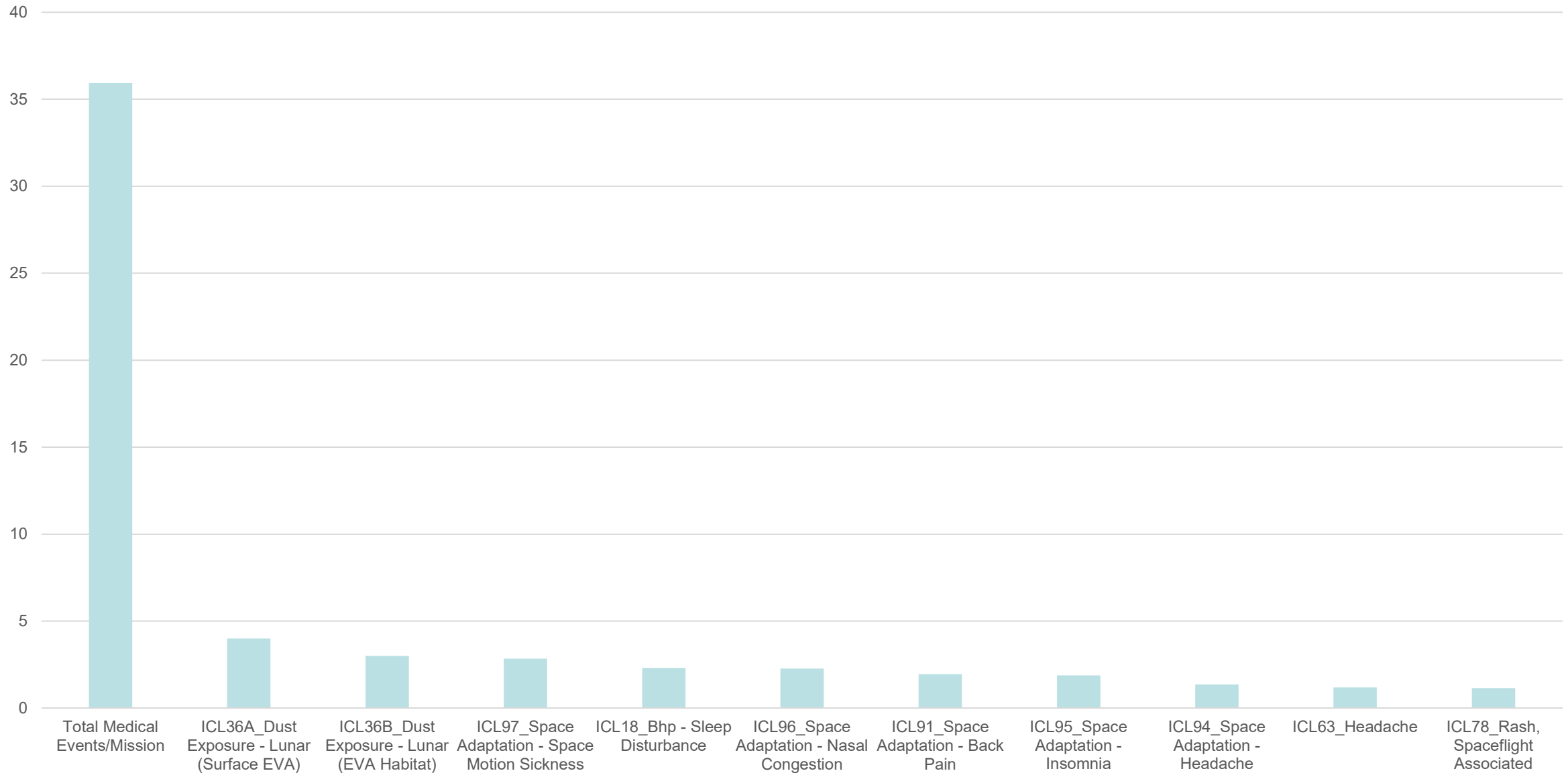
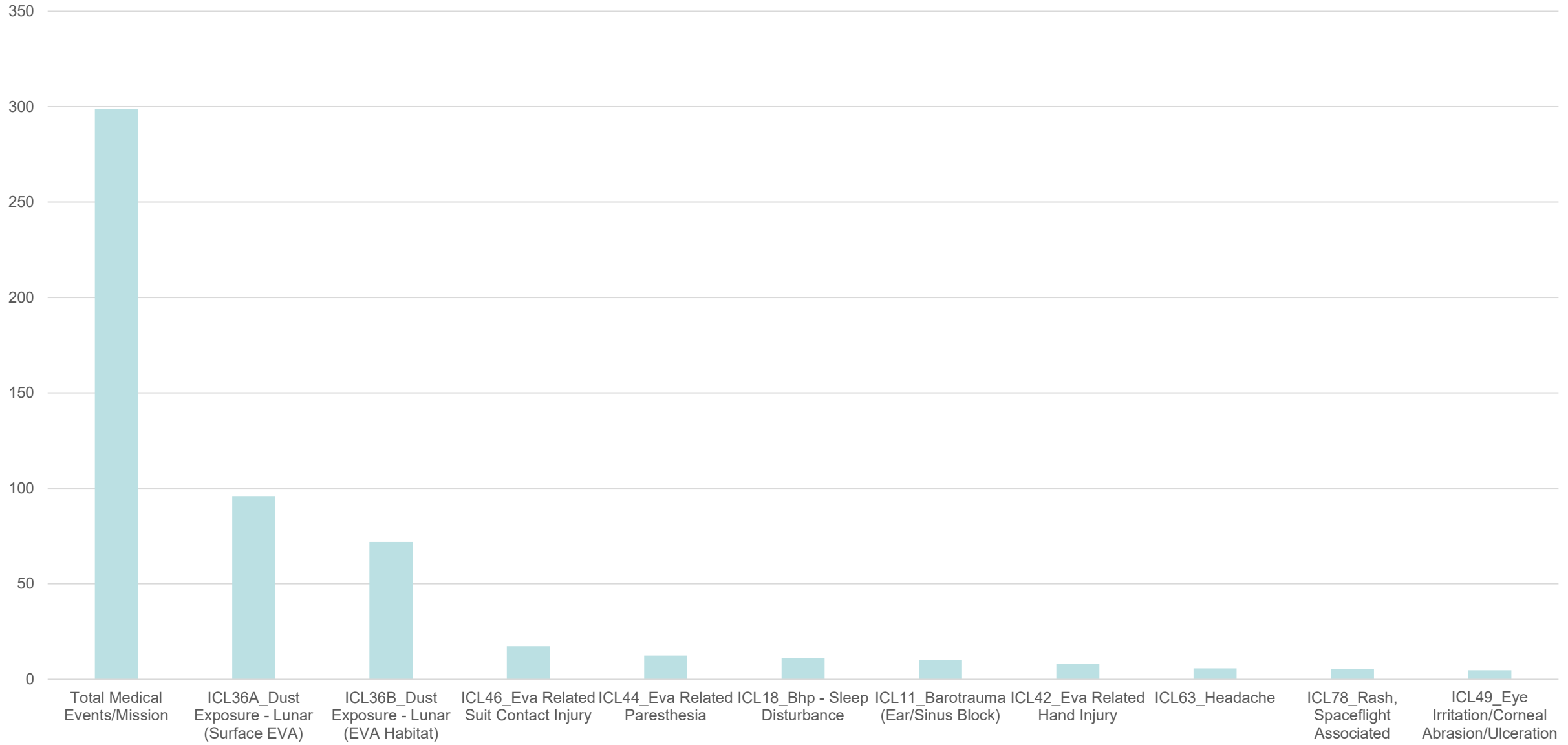


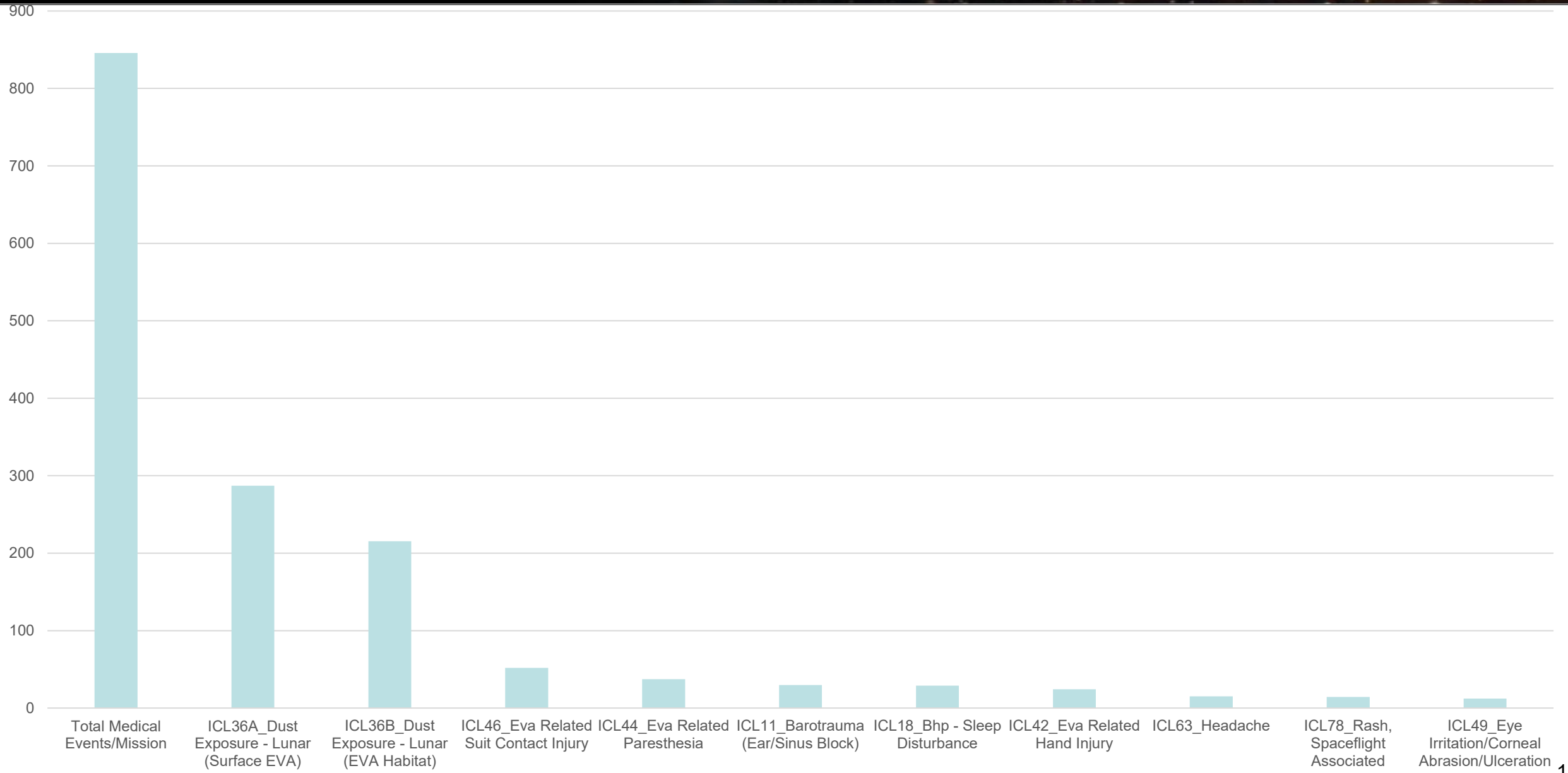
Chart Title



# Standard Duration Mission Events



# Long Duration Mission Events



# Comparing Occurrence by Mission Length

Short		Baseline		Long	
Total Medical Events/Mission	35.9	Total Medical Events/Mission	298.7	Total Medical Events/Mission	845.6
ICL36A_Dust Exposure - Lunar (Surface EVA)	4.0	ICL36A_Dust Exposure - Lunar (Surface EVA)	95.9	ICL36A_Dust Exposure - Lunar (Surface EVA)	287.2
ICL36B_Dust Exposure - Lunar (EVA Habitat)	3.0	ICL36B_Dust Exposure - Lunar (EVA Habitat)	71.9	ICL36B_Dust Exposure - Lunar (EVA Habitat)	215.4
ICL97_Space Adaptation - Space Motion Sickness	2.8	ICL46_Eva Related Suit Contact Injury	17.3	ICL46_Eva Related Suit Contact Injury	51.9
ICL18_Bhp - Sleep Disturbance	2.3	ICL44_Eva Related Paresthesia	12.4	ICL44_Eva Related Paresthesia	37.3
ICL96_Space Adaptation - Nasal Congestion	2.3	ICL18_Bhp - Sleep Disturbance	11.0	ICL11_BaroTrauma (Ear/Sinus Block)	29.9
ICL91_Space Adaptation - Back Pain	2.0	ICL11_BaroTrauma (Ear/Sinus Block)	10.0	ICL18_Bhp - Sleep Disturbance	29.2
ICL95_Space Adaptation - Insomnia	1.9	ICL42_Eva Related Hand Injury	8.1	ICL42_Eva Related Hand Injury	24.3
ICL94_Space Adaptation - Headache	1.4	ICL63_Headache	5.7	ICL63_Headache	15.1
ICL63_Headache	1.2	ICL78_Rash, Spaceflight Associated	5.4	ICL78_Rash, Spaceflight Associated	14.4
ICL78_Rash, Spaceflight Associated	1.2	ICL49_Eye Irritation/Corneal Abrasion/Ulceration	4.7	ICL49_Eye Irritation/Corneal Abrasion/Ulceration	12.4



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- Short Duration Mission (7d)
  - More procedure and airway supplies
    - Eg NPA, OPA, Ambu bags
  - Fewer Medications



- Long Duration Mission (505d)
  - More medications
    - Almost every medication
  - Lots of EVA related medications (eg cough medication, anti-inflammatories)
  - Very few life saving devices....



- **Number of EVAs**
  - Chosen based on reasonable estimate of EVA rate
- **Medical System Size**
  - Shorter likely more constrained
  - Driving more life saving interventions
- **Condition Frequency vs Acuity**
  - Data driven but may not provide emergent resources

- **Longer Mission Durations**
  - Heavily invested in resources it sees as “most valuable”
  - Represents how model performs
- **Shorter missions carry more broad variety of resources/devices**
  - Has more space for other things?
  - System size disproportionately large?
- **Medium duration missions**
  - Goldilocks
  - May have most “accurate” system due to the way IMPACT designed

- **Short and Long Duration Missions have different effects on risk profiles...**
  - ...But not how we expected
- **EVAs introduce a substantial amount of medical risk**
  - Medical systems should consider targeting these conditions
  - We are less experienced with high volumes of EVA
  - There is greater uncertainty in the model and risk outcomes
- **The model performs in the way it was designed**
  - Initial goal was to target 200d lunar missions
  - Large deviations from this DRM may require some retooling



# Questions?

“Expanding the Boundaries of Space Medicine and Technology”