Medical Training Requirements for Exploration Medicine Compared to Current Terrestrial Training Programs

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Background

Purpose: To describe terrestrial medical specialty training requirements in comparison to anticipated needs of future Exploration Crew Medical Officers (ExMOs) and secondarily to outline one method for how specialty specific training may be applied as a factor in Probabilistic Risk Analysis (PRA) tools to better assess mission risk based on crew medical training.

Low Earth Orbit (LEO) space operations are supported by a robust International Space Station (ISS) medical capability and near continuous contact with ground flight surgeons. Emergency medical evacuation from ISS may be accomplished in less than 24 hours, but may take up to 2 weeks from lunar orbit and may not be feasible during Mars missions.

As humans venture beyond LEO, timely earth-based terrestrial medical support and communications will be limited or non-existent. The crew's medical autonomy, referred to as Earth Independent Medical Operations (EIMO) is essential, and will be achieved through Exploration Crew Medical Officer (ExMO) training to manage expected medical events independent of terrestrial support.(2)

The opinion on the best staffing model to meet this standard often varies depending on the level of training and specialty of the medical provider being asked. This project provides a data based framework to inform the answer to this question through analysis of expected physician capabilities as noted in the medical specialty requirements.

Methods

A NASA-convened group of medical experts created a list of the clinical knowledge, skills, and abilities (KSAs) required to manage anticipated medical events occurring during long duration space missions for the Informing Mission Planning by Analysis of Complex Tradespaces (IMPACT) preliminary evidence library. (1)

In this project the physician level KSAs were analyzed against the core curriculum requirements as denoted by the Accreditation Counsel of Graduate Medical Education (ACGME) for five medical specialties. In addition, the American Board of Emergency Medicine Core Curriculum and American Academy of Family Physicians Residency Curriculum Guidelines provided additional detailed requirements.

The ACGME requirements for the specialty of Aerospace Medicine are exceptionally broad and specific competencies from a specialty board or professional society are not readily available, leading to the use of expert opinion as a reference for the capabilities of an Aerospace Medicine trained Physician.

This analysis provides a data driven comparison of skills in each specialty that can be analyzed against the expected KSAs needed for success for each Mission's anticipated medical needs. These skill sets also enable the ability to analyze gaps in physician-CMO's individual experience to identify additional mission specific training needs as well as skills maintenance and just-in-time training both pre-mission and in-flight.

Data

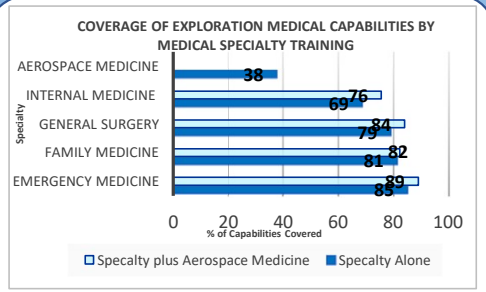

Figure 1: Coverage of Exploration Medical Capabilities by Medical Specialty Training. A total of 297 capabilities were identified, with varying amounts covered by each residency

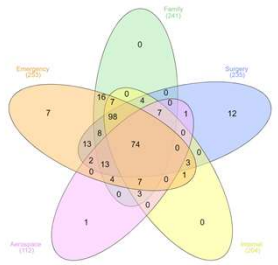

Figure 2: Overlap of Capability Coverage. 16 KSAs are not covered by any specialty and are not depicted in this graph

No Specialties	1 Specialty	2 specialties		3 specialties			4 specialties										5 specialties							
1	482	2	479	6	455	722	23	436	580	13	73	410	452	488	505	545	594	618	634	867	3	26	51	84	429	587	843
24	741	42	597	7	467	868	52	438	601	18	81	412	458	489	506	571	595	619	638	984	4	27	58	85	441	591	844
25	767	49	598	54	470	913	53	465	606	28	105	422	460	490	508	581	596	620	641	1024	5	37	59	123	448	593	
33	768	50	599	72	486	914	63	472	637	29	191	432	464	491	511	582	600	621	642	1044	11	38	61	136	450	608	
34		68	603	97	498	940	86	481	821	30	230	433	466	492	513	583	602	622	648	1063	14	39	64	231	456	611	
57		74	629	121	501	963	163	484	822	31	255	434	468	494	514	584	604	623	650		15	40	65	360	457	612	
60		75	742	126	509	2002	303	485	824	32	366	435	469	495	516	585	605	624	793		16	41	66	363	459	614	
137		82		143	512		304	487	1043	35	387	445	473	497	517	586	607	625	794		17	43	67	400	476	626	
179		83		170	649		405	493		36	402	446	474	499	518	588	613	627	795		19	44	69	401	477	628	
183		168		180	685		406	507		55	404	447	475	500	519	589	615	630	800		20	45	70	403	478	631	
198		190		214	686		407	510		56	408	449	480	502	521	590	616	632	819		21	47	71	421	496	635	
226		471		327	721		411	579		62	409	451	483	503	525	592	617	633	820		22	48	80	426	515	636	

Chart 1: KSAs for long duration spaceflights sorted by the number of specialties that train to that capability. These capabilities were derived by NASA experts from the expected medical events crews may face on long duration missions..

References:

1. Dana R. Levin, et.al A Method for Capturing the Mass and Volume Cost of Medical Treatment. (pre-publication review)
2 Dana R. Levin, et.al. Enabling Human Space Exploration Missions Through Progressively Earth Independent Medical Operations (EIMO) IEEE Open Journal of Engineering in Medicine and Biology submitted October 2022.
3 D. Rubin et al. (2020 Feb) Recommendation for a Medical System Concept of Operations for Gateway Missions: NASA HRP Investigators Workshop. Galveston, TX (Online) Available: https://ntrs.nasa.gov/citations/20200001341
4 Heberle, H.; Meirelles, G. V.; da Silva, F. R.; Telles, G. P.; Minghim, R. ***InteractiVenn: a web-based tool for the analysis of sets through Venn diagrams***. BMC Bioinformatics 16:169 (2015).

Discussion

Analysis of this data set in reference to Exploration Mission success reveals:

No single medical specialty training will provide all the essential KSA requirements

Primary training in Emergency Medicine with additional board certification in Aerospace Medicine (AM) covers **89%** of the anticipated competencies, the most comprehensive training of the four specialties combined with AM.

Aerospace Medicine training alone covers 38% of the KSAs, but in combination covers: 84 % with General Surgery; 82% with Family Medicine; 76 % with Internal Medicine

With greater experience on the new and challenging clinical requirements for long duration space flight, terrestrial training programs will be well suited to evolve and meet the anticipated clinical needs of deep space missions and to fully prepare ExMOs for the clinical care needs of astronauts.

Limitations: ACGME requirements were written broadly, and the core curriculum requirements were not uniformly detailed, making rigorous direct comparisons problematic . Similarly, this research did not take into account individual physician expertise or experience, which may impact the ExMO selection process.

Conclusions

For Exploration Crew Medical Officers (ExMO) :

No single physician specialty training program covers every identified KSA that was recommended.

There are 16 KSAs that are not addressed in any training program.

Current training for terrestrial physicians may need to be adapted to meet the needs of future exploration medical officers

Creation of a Capability Check List may be beneficial to ensure ExMO candidates are trained to meet the expected mission medical requirements

Future analysis could develop an essential clinical skill set/training requirement desired for all crewmembers as well as complimentary skill sets for secondary medical officers to best cover long duration missions