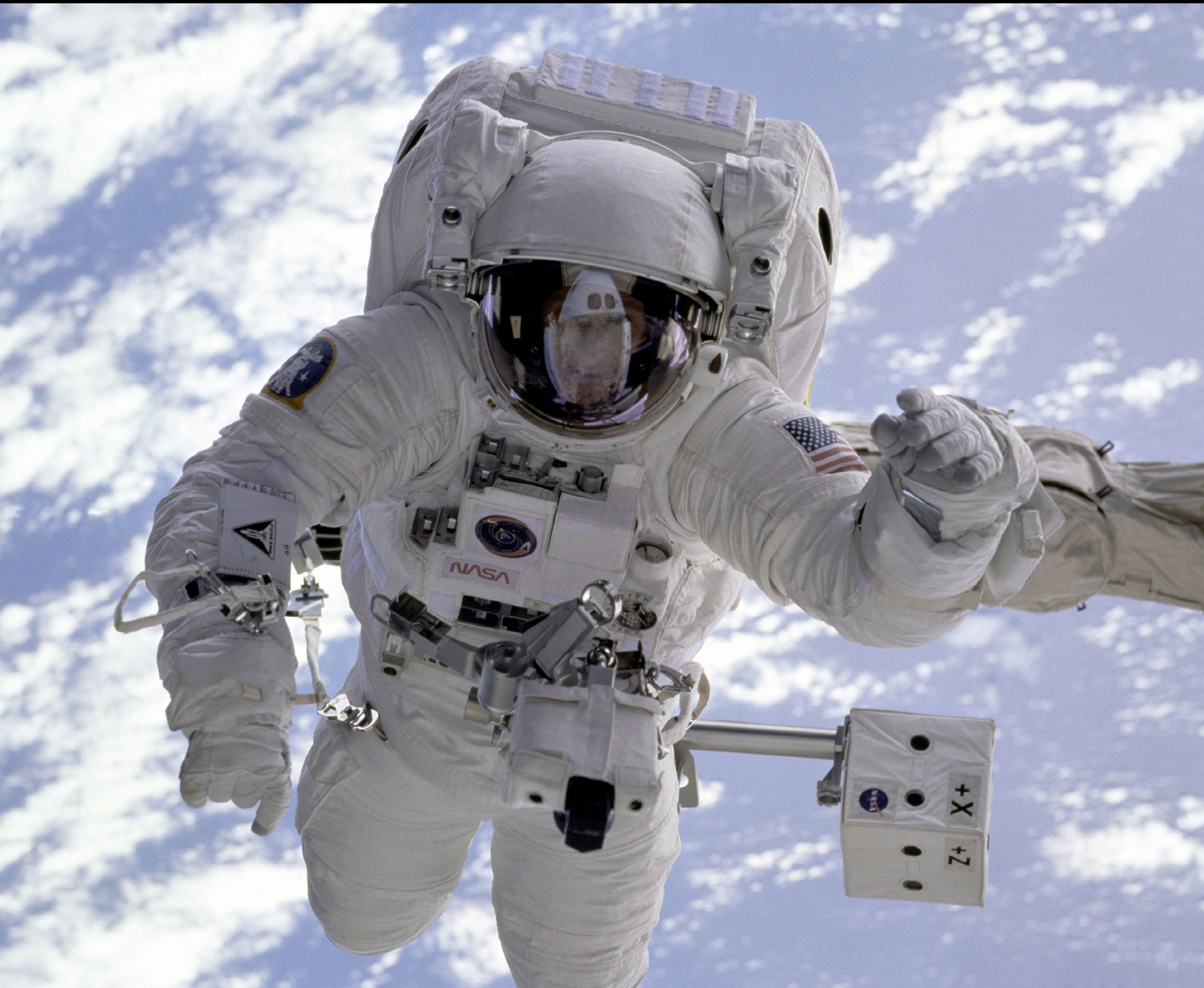
AEROSPACE MEDICAL EDUCATION CORE COMPETENCIES

EXTENDED EXECUTIVE SUMMARY



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INTRODUCTION

Aerospace medicine has existed as a medical specialty since the early 1900s[1] and originated alongside the development of the aviation industry. According to the Aerospace Medicine Association, aerospace medicine involves determining and maintaining the health, safety, and performance of humans involved in air and space travel.[2] This encompasses both aviation medicine (i.e., involving airplane pilots and air flight) and space medicine (i.e., involving astronauts and spaceflight). Flight surgeons can be broadly defined as expert aerospace medicine providers, and individual organizations may use the term differently. For the purposes of this report, we have used the terms "aerospace medicine practitioner" or "aerospace medicine provider" to refer to individuals who are trained in aerospace medicine and provide medical care to aviators, astronauts, or other spaceflight participants.

Historically, space medicine was combined with aviation medicine in part because few space medicine physicians were required for the limited number of human spaceflight missions from the National Aeronautics and Space Administration (NASA) and a handful of other government space agencies. Today, the reinvigoration of NASA's space campaign with the Artemis Program, the recent boom in commercial spaceflight companies, the establishment of the United States Space Force (USSF), and increasing involvement from other nations are rapidly expanding the astronaut workforce and participation in human spaceflight. However, many aerospace medicine providers will point out that getting to the space environment requires passing through the air environment, and many of the concerns of aviation medicine also apply to space medicine. As such, separating out these two types into separate medical domains is not entirely sensible.

Similarities between aviation medicine and space medicine are due in part to the fact that many of the hazardous and/or unusual elements in the aviation environment are also present in the space environment. For example, isolation and enclosure are factors that can affect both physical and mental health of both astronauts and pilots. Similarly, both astronauts and aviators are exposed to extended periods of vibration and noise; astronauts on the International Space Station (ISS) are exposed to this for a more extended period of time, but the change is a matter of degree, not of essential difference. Radiation exposure is present in both the aviation and space environments, although to a greater extent in the space environment. Conversely, the main factor that characterizes the space environment but not the aviation environment is microgravity.

Aerospace medicine providers working in space medicine are responsible for many aspects of patient care throughout the mission duration. At NASA, care begins when aerospace medicine providers conduct comprehensive medical evaluations as part of the astronaut selection campaign. This entails screening astronaut candidates for their general health status and evaluating them for any disqualifying medical conditions. As our knowledge of the impacts of the aerospace environment on human physiology evolves, these medical standards are evaluated and adjusted. NASA is currently in such an evaluation process and is soliciting public comments to revise the current astronaut medical standards, requirements, and clinical procedures used to medically evaluate astronauts.[3]

Following astronaut selection and certification, NASA aerospace medicine providers become the primary care physicians for the astronaut team members. They provide care and support through training, launch, flight, and landing, and continue with longitudinal care throughout the astronauts' lifespans. These aspects are unique to aerospace medicine compared to other medical specialties. Aerospace medicine providers need to possess a wide range of medical knowledge to inform care throughout each astronaut's mission and lifespan. Each phase brings unique risks and physiological changes that the provider should be able to recognize, diagnose, and treat.

GROWTH OF COMMERCIAL SPACEFLIGHT AND RAPIDLY CHANGING SPACE ECOSYSTEM

Recent years have been characterized by a rapid increase in commercial spaceflight, which may precipitate an increased need for individuals trained in space medicine. Further, commercial spaceflight companies have different criteria for who can go to space compared to historical standards set by NASA and other international spaceflight agencies. Currently, there are no official medical standards for U.S. spaceflight participants; because of this, commercial space companies are in the process of developing those individually, and they will likely not be the same across companies without federal government input. This means that older and/or less healthy individuals may be flying, which could alter the medical conditions that will need to be treated in space or post-flight. Further, there are some medical conditions for which the impact of spaceflight is entirely unknown. For example, there has never been a spaceflight by a person with known diabetes.

The rapidly changing environment of spaceflight will likely result in many unprecedented cases of passengers flying with unique medical conditions, which will in turn necessitate medical practitioners who have the skills, knowledge, and experience to make informed decisions. Developing a robust understanding of core medical competencies and data-driven health practices underpins a safe and successful continued development in the human spaceflight endeavor.

AEROSPACE MEDICAL EDUCATION AND TRAINING TODAY

Five aerospace medicine training programs accredited by the Accreditation Council for Graduate Medical Education (ACGME) are currently active in the United States. Each leads to American Board of Preventive Medicine (ABPM) board certification. The training programs include military programs at U.S. Air Force School of Aerospace Medicine, Naval Aerospace Medical Institute, and U.S. Army School of Aviation Medicine. Two civilian programs are run by the University of Texas Medical Branch (UTMB) and the Mayo Clinic in Rochester, Minnesota. Additionally, two similar but discontinued civilian programs existed at Wright State University and University of Texas Houston Medical Center in partnership with Johnson Space Center (JSC). Each of these aerospace medicine training programs require an existing medical degree and clinical experience for admission.[4] All programs divide participants' time between classroom education, which often incorporates a Master of Public Health degree, and practical experience, which can include field rotations with NASA, the military, and commercial companies.

Aerospace medicine residency programs require external funding sources in order to train those taking part in the program, unlike fellowships, which produce revenue through fellows' work hours in medical facilities.[5] Most medical residencies receive federal funding through the Department of Health and Human Services.[6] However, aerospace medicine residencies do not receive this funding. Instead, aerospace medicine residencies are typically funded by NASA or the military, resulting in limited numbers of programs and residency slots.[7]

Terminology for aerospace medicine provider roles varies depending on the organization. At NASA, aerospace medicine providers have various experiences and job titles ranging from flight surgeon to leadership roles such as chief medical officer. Typically, NASA flight surgeons have been trained and are board-certified in aerospace medicine and another medical specialty, representing over four years of academic specialty education and experience prior to starting their position. In the Air Force, however, providers who have completed an aerospace medicine residency typically work as aerospace medicine specialists. This is a higher-level role than an Air Force flight surgeon, as specialists are qualified to contribute to policy and other advanced decisions. Air Force flight surgeons must be licensed physicians and have completed the 6-to-10-week Air Force course on aerospace medicine fundamentals. For Air Force flight surgeons to qualify for the residency program and become aerospace medicine specialists, they must spend two years on the job as a flight surgeon. Roles in other organizations include aviation medical examiners in the Federal Aviation Administration (FAA), and contractor, flight surgeon, or chief medical officer in the commercial sector.

CENTRAL RESEARCH QUESTION

The Potomac Institute for Policy Studies undertook the current study at the request of the Office of the Chief Health and Medical Officer (OCHMO). The purpose of the study is to understand the central research question: "What core competencies do aerospace medicine practitioners require to perform their duties?" Although aerospace medicine includes aviation medicine, for this study's purposes, the study team focused on space medicine and astronaut care.

CORE COMPETENCY AREAS

Based on interviews with aerospace medicine providers, the Institute identified four high-level core competency areas, which highlight the necessary skills and knowledge to perform duties associated with the role of aerospace medicine:

- Clinical Expertise,
- Knowledge of the Aerospace Environment,
- Professional Skills, and
- Operational Skills.

Further sub-categories for each of these areas have been identified and are detailed below, including second and third level core competencies. This is not an exhaustive list of every skill and technique necessary, but highlights sub-skills or examples of additional skills and techniques identified by subject matter expert (SME) interviews and internal research. It should be noted that this study placed particular emphasis on space medicine, albeit with the recognition that space medicine and aviation medicine are deeply intertwined. Therefore, some competencies described here apply to both aviation and space medicine, and others are primarily or only applicable to space medicine. Further, competency requirements for specific jobs may have additional requirements, or may not require all of the skills described here.

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Each skill or knowledge area has also been categorized with the following indicators of the level of expertise required and applicability to specific settings (Figure 1).

APPLICABILITY	
G	General medical core competency *applicable to a wide variety of medical practices*
S	Specific competency *applicable to space medicine in a way that might deviate from or expand on general competency*
C	Commercial competency *may be more applicable to commercial spaceflight*

EXPERTISE	
1	Basic understanding or limited working proficiency
2	Skill mastery or significant expertise

Figure 1. Ratings for competency areas based on applicability to specific settings and level of expertise required. Image: Potomac Institute for Policy Studies.

IDENTIFYING THE AEROSPACE MEDICINE PATIENT

For this report, the study team has defined the typical patient for the aerospace medical provider as an individual who will be and/or has been exposed to the space environment. Depending on the astronauts' organizational affiliation, exposure duration may vary widely from minutes to months. NASA identifies five hazards during spaceflight that pose a risk to human health: space radiation, isolation and confinement, distance from Earth, gravity, and closed or hostile environments.[8] Importantly, these hazards do not exist alone; they interact with each other to create unique effects on human physiology in a way that is not typically seen terrestrially. While the physiological systems themselves do not change, their ability to and efficacy of function can drastically change. These hazards also impact each individual differently and changes may not manifest in the same way. Therefore, aerospace medicine practitioners must be aware of the different physical manifestations and be able to identify these changes and develop an appropriate treatment plan if necessary.

1. CLINICAL EXPERTISE:

Demonstrated ability to provide routine clinical care to a patient; includes "be a good doctor," general diagnostic skills, and specific medical expertise areas relevant for astronaut care. Clinical Expertise includes the following sub-categories:

1.1. FUNDAMENTAL CLINICAL SKILLS:
Evaluate, diagnose, and decide on clinical treatment plans and execute treatment plans

- 1.1.1. Patient History and Physical Examination (G2)
- 1.1.2. Diagnosis and Treatment of Medical Conditions (G2)
- 1.1.3. Procedural Skills (G2)
- 1.1.4. Patient Documentation (G2)
- 1.1.5. Patient Communication (G2)

1.2. CARE FOR PATIENT IN EMERGENCY SETTING:
Provide emergency care for illness or injury; includes interventions for unforeseen medical conditions such as life-threatening cardiovascular events or trauma

- 1.2.1. Disaster/Emergency Response in the Field (S1)
- 1.2.2. Contingency Launch and Landing Response (S1)
- 1.2.3. Medical Evacuation (S1)
- 1.2.4. Point of Injury Care (G1)
- 1.2.5. Provide Care with Limited Resources (G2)

1.3. PROVIDE CARE IN A TERRESTRIAL AUSTERE ENVIRONMENT:
Anticipate health risks, implement countermeasures, and perform medical care in austere and/or hostile settings

- 1.3.1. Travel Medicine (G1)
- 1.3.2. Provide Care with Limited Resources or Constraints (S2)
- 1.3.3. Prioritize Competing Needs (G2)
- 1.3.4. Work Through Environmental Stressors (G2)
- 1.3.5. Design, Maintenance, and Use of Field Medical Kits (S1 - C1)

1.4. TELEMEDICINE:
Remotely diagnose and guide patient treatment; includes directing self-examination, provide anticipatory guidance, and communicating empathy without a physical presence

- 1.4.1. Communicate Via Video or Voice Call (G2)
- 1.4.2. Manage Communication Delays (S2)
- 1.4.3. Effectively Communicate to Non-Medical Provider (G2)
- 1.4.4. Direct Patients in Self-Examination (G2)

1.5. PREVENTIVE MEDICINE:

Provide preventive care and maintain health and well-being; includes treating people in an abnormal environment and mitigating impact of co-morbidities; understanding of principles and implementation of relevant countermeasures

1.5.1. General Health and Disease Maintenance (e.g., cardiovascular, neurological, respiratory, musculoskeletal, metabolic) (G2)
1.5.2. Risk Assessment and Countermeasure Implementation (S2)
1.5.3. Epidemiology and Biostatistics (S2)
1.5.4. Infectious Disease Prevention and Management (G2)
1.5.5. Tropical and Global Health Medicine (S2)
1.5.6. Environmental Disease Prevention and Management (S2)

1.6. OCCUPATIONAL MEDICINE:

Predict, mitigate, evaluate, treat, and monitor injury and illness resulting from exposure to occupational hazards (terrestrial and aerospace environment)

1.6.1. Risk Assessment and Management (S2)
1.6.2. Chronobiology and Fatigue Management (S1)
1.6.3. Post-Flight Rehabilitation and Return to Normal Life (S2)
1.6.4. Longitudinal Health Surveillance (S2)
1.6.5. Occupation Hazards and Regulations During Ground Operations (S2)
1.6.6. Development and Implementation of Organizational Habitability and Exposure Standards (S2 – C2)
1.6.7. Toxicology (S1)

1.7. BEHAVIORAL HEALTH:

Diagnose and/or treat mental health, stress, and related issues; includes understanding of isolation and confinement, recognizing the bio-psycho-social foundation of behavioral health issues, knowledge of associated physical symptoms, and supporting the use of coping mechanisms

1.7.1. Provide Psychological Support to Crew (S1)
1.7.2. Support Staff and Crew Family Support (S1)
1.7.3. Psychiatry Management (S1)
1.7.4. Screen for Risk Factors (S2)
1.7.5. Early Identification of Behavioral Deviations (S2)

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2. KNOWLEDGE OF THE AEROSPACE ENVIRONMENT:

Understand relevant scientific concepts relating to the aerospace environment and impact of that environment on physiology. Apply evidence-based principles and leverage understanding of the medical literature to inform patient care decisions. Knowledge of the Aerospace Environment includes the following sub-categories:

2.1. HUMAN HEALTH RISKS OF SPACEFLIGHT:
Understand and mitigate the human health risks associated with altered physiology in an altered environment

- 2.1.1. Acceleration and Gravitational Effects Including Microgravity (S2)
- 2.1.2. Cardiovascular (S2)
- 2.1.3. Neurological and Cognitive Changes (S2)
- 2.1.4. Ocular (S2)
- 2.1.5. Fluid Shifts (S2)
- 2.1.6. Hypoxia (S2)
- 2.1.7. Pressure (Hyper and Hypobaric) Effects (S2)
- 2.1.8. Radiation Exposure (S2)
- 2.1.9. Musculoskeletal (S2)

2.2. RISK EVALUATION:
Assess and quantify risk (individual, crew, and mission) during all mission phases to inform decision-making

- 2.2.1. Pre-Flight Training and Preparation (S2)
- 2.2.2. Launch (S2)
- 2.2.3. Flight (S2)
- 2.2.4. Extravehicular Activities (S2)
- 2.2.5. Landing (S2)
- 2.2.6. Emergency Egress (Launch or Landing) (S2)
- 2.2.7. Post-Landing Rehabilitation (S2)
- 2.2.8. Risk Human Brings to the Mission (S2)

2.3. MISSION-SPECIFIC KNOWLEDGE:
Awareness of organization-specific technologies, systems, and mission design and their potential impact on crew health

- 2.3.1. Ground Support (S1)
- 2.3.2. Vehicles (S1)
- 2.3.3. Phases of Flight (S1)

2.4. HUMAN SYSTEMS INTEGRATION:
Apply human-centered design principles, including medical system design, habitat, lighting, task analysis, and vehicle design

- 2.4.1. Human Factors (S1)
- 2.4.2. Human Technology Interfacing (S1)
- 2.4.3. Human Automation/Robotic Systems (S1)

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3. PROFESSIONAL SKILLS:

Experience and expertise in "soft skills," such as effective communication (including risk communication), leadership abilities, demonstrated teamwork, and management capabilities. Professional Skills includes the following sub-categories:

3.1. BEDSIDE MANNER AND COMMUNICATION:
Effectively communicate with patients and crew; includes building trust with crew members and advocating for crew/patients

- 3.1.1. Emotional Intelligence (G2)
- 3.1.2. Build Trust and Rapport with Crew and Families (G2)
- 3.1.3. Understand Specific Pressures of the Job and Impact on Patients (S2)
- 3.1.4. Interact with High-Profile Individuals (S2)
- 3.1.5. Communicate Policy and Procedures (G2)

3.2. INTERACT AND COLLABORATE WITH ENGINEERS:
Communicate medical concepts to engineers and provide medical-related inputs to the engineering process; includes quantifying medical risks and providing input on vehicle design and other engineering products

- 3.2.1. Engineering Terminology, Requirements, and Processes (S1)
- 3.2.2. Quantify and Communicate Risk (S2)
- 3.2.3. Communicate Human Systems Integration and Human Factors Design (S1)

3.3. INTERACT AND COLLABORATE WITH SCIENTIFIC RESEARCHERS:
Communicate medical concepts and research with scientific community and advise investigators on astronaut health risks to inform research protocol design

- 3.3.1. Advocate for Astronaut Well-Being (S2)
- 3.3.2. Communicate Risk Associated with Study Participation (S2)
- 3.3.3. Communicate Research Impact (S2)

3.4. INTERACT AND COLLABORATE WITH NON-TECHNICAL STAKEHOLDERS:
Communicate concepts to non-crew and non-engineer stakeholders in a way that distills technical problems into an understandable and actionable decision

- 3.4.1. Quantify and Communicate Risk (S2)
- 3.4.2. Explain Scientific and Medical Concepts with Language and Concepts Appropriate for the Audience (G2)

3.5. TEAMWORK:
Work as part of a cohesive team and to be able to lead or follow as the situation dictates

- 3.5.1. Collaborate Within an Interdisciplinary Team (G2)
- 3.5.2. Team Leadership (G2)
- 3.5.3. Consult with Other Experts When Necessary (G2)
- 3.5.4. Project Management (S1 – C1)

3.6. CONTINUING EDUCATION AND LEARNING:
Research relevant scientific concepts, stay up to date on literature, and appraise scientific merit; desire and active participation to continue education and improvement of knowledge and skills as scientific and medical fields advance

3.6.1. Stay Current on Scientific Literature (G2)
3.6.2. Critically Evaluate Research Design and Findings (G2)
3.6.3. Upkeep of Clinical Skills (S2)
3.6.4. Continuing Education in Medical Practice (G2)

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4. OPERATIONAL SKILLS:

Ability to work human spaceflight missions and experience with spaceflight-specific operational procedures. Operational Skills includes the following sub-categories:

4.1. MEDICAL CERTIFICATION AND EVALUATION PROCESS:
Conduct aeromedical evaluations and understand, develop, update, and/or apply medical standards; includes determining fitness for duty parameters, providing medical waivers, understanding relevant certification and/or qualification processes

- 4.1.1. Selection and Retention Medical Certification Standards (S2)
- 4.1.2. Medical Waiver Process (S2)
- 4.1.3. Develop Medical Waiver Rationale as Needed (S2)
- 4.1.4. Communicate Risk-Assessment to Decision Makers (S2)

4.2. OPERATIONS AND MISSION CONTROL:
Work on and adapt to changes in spaceflight missions, and work console; includes operating as a member of the Flight Control Team in the Mission Control Center

- 4.2.1. Standard Processes, Procedures, Flight Rules, and Technology in Mission Control (S2)
- 4.2.2. Effective and Timely Communication with Flight Control (S2)
- 4.2.3. Nominal Launch and Landing Response (S2)
- 4.2.4. Medical Transport (S2)

4.3. WORK WITH ORGANIZATIONAL PARTNERS:
Function effectively within home organization and jointly with partner government, commercial, or international entities; includes working with different cultures and diverse teams

- 4.3.1. Military (S1)
- 4.3.2. International Partners (S1)
- 4.3.3. Government Agency Interactions (S1)
- 4.3.4. Commercial Companies (S1)

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4.4. MISHAP PREVENTION, INVESTIGATION, AND RESPONSE:
Apply specialty medical and human factor expertise to develop spacecraft requirements, and respond to and investigate spacecraft mishaps

- 4.4.1. Develop Preventive Plans and Incident Management Procedures (S2)
- 4.4.2. Contingency Launch and Landing Response (S2)
- 4.4.3. Coordinate with Mishap Response Agencies (S1)
- 4.4.4. Post-Incident Safety Reviews (S2)
- 4.4.5. Crowd Management (S1)

4.5. POLICY, REGULATIONS, AND PROCEDURES:
Understand current and evolving regulations and procedures; includes working within federal, political, organizational, and regulatory restraints

- 4.5.1. Regulations and limitations of data sharing (S1)
- 4.5.2. Interpret policy documents and apply medical standards (S2)

CONCLUSIONS AND RECOMMENDATIONS

The landscape of spaceflight is changing swiftly, as recent years have seen a rapid increase in commercial spaceflight, the introduction of the USSF, increased involvement from other nations, and NASA's increased focus on its Moon to Mars architecture. Therefore, there is a concomitant increase in the need for aerospace medicine providers to protect the health and well-being of these astronauts and spaceflight participants. The changing patient population underscores the need for re-evaluating the training aerospace medicine providers receive to ensure they are prepared and able to provide appropriate care.

The Potomac Institute for Policy Studies was tasked by OCHMO to determine the training, skills, knowledge, and core competencies necessary for aerospace medicine providers, particularly in the space medicine domain. Using data integrated from the literature review and iterative interviews with SMEs, the Institute identified four high-level core competency areas an aerospace medicine provider needs training in to ensure they are prepared to provide the necessary care:

- Clinical Expertise,
- Knowledge of the Aerospace Environment,
- Professional Skills, and
- Operational Skills.

Each of these four high-level core competency areas is supported by second- and third-level competencies. While this list is not exhaustive for every organization, it identifies the skills and knowledge necessary to practice as an aerospace medicine provider. It is important to note that not all skills and knowledge are mastered during residency training; on-the-job training and exposure to experienced aerospace medicine practitioners supplement residency training to create well-rounded, well-informed providers. Further, not every aerospace medicine provider will need the same set of skills and knowledge. Aerospace medicine providers who support NASA missions may need different skills than those who support commercial missions.

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Based on findings and analysis of this report, the Potomac Institute developed the following recommendations regarding aerospace medicine training, skills, and knowledge:

1. **Frequently re-evaluate and document all aerospace medicine training program requirements, including informal and practical experience components.** The rapidly changing field of human spaceflight and the corresponding expansion of the duties of aerospace medicine providers necessitates equally flexible training programs.
2. **Incorporate input from individuals with experience in working with commercial spaceflight companies as well as NASA in the evaluation process.** The expanded role that commercial spaceflight companies play in human spaceflight should be acknowledged and incorporated into the training process. Where possible, trainees should be given the opportunity to learn from aerospace medicine providers from a wide range of experiences to better prepare them for future collaborations and cooperative efforts.
3. **Ensure continued skill development for aerospace medicine providers after training programs are completed.** Continuing Medical Education is an important component of maintaining medical licensure. As residency programs in aerospace medicine continue to develop and improve training opportunities, currently licensed providers should also be allotted time and funding with which to participate in those opportunities.

The Aerospace Medicine discipline is unique among medical fields in that providers must be equipped to identify, diagnose, and treat physiological changes not typically encountered in terrestrial medicine training and practice. Astronauts and spaceflight participants are exposed to unique hazards, which can cause unexpected physiologic changes and manifestations. Historically, astronauts exposed to the spaceflight environment were of the highest standards of health. Because of this, the adage was to "keep healthy people healthy." However, this no longer holds true, as the diversity of individuals with varying health statuses can reach the space environment through a variety of means. Therefore, the adage may now adapt to "keep people with co-morbidities or health risk factors from degrading or deconditioning to a critical point." This requires a new approach to training because aerospace medicine practitioners are encountering manifestations that have not been seen before because individuals with these risk factors have not been sent to space before. As the patient population changes, the training required to provide the standard of care evolves, too.

Practitioners must develop and apply standards to individuals to reduce the risk of adverse medical events, and review those standards over time, as additional data is collected and as flight capabilities improve and change. The fundamental skills and knowledge required by aerospace medicine specialists reflect these tasks, with an understanding of the aerospace environment being cited as the most important requirement for practitioners.

The mindset of preventive medicine is also fundamental to the practice. The resources available during spaceflight are severely limited by the mass and volume of materials and equipment that can be brought to space. It is therefore far more important and efficient to prevent adverse medical events before they occur, rather than attempting to treat them.

Communication skills are also essential, both with the crew (or spaceflight participants, as in the case of commercial space flights) and with all other individuals involved in designing and carrying out missions. The flight surgeon serves as the advocate for their patients, and bears the responsibility of looking out for their health and safety. Building trust and rapport between the patient and the practitioner will be especially important for long-duration exploration spaceflight, where crew members could be years away from definitive care.

METHODOLOGY

Below is a brief summary of the data collection and analysis approach. A more detailed look at the methodology can be found in the full report.

To develop findings and recommendations on aerospace medicine training and core competencies, the Potomac Institute conducted a literature review and interviews with stakeholders and SMEs. The literature review included reviewing official medical requirements (i.e., the Accreditation Council for Graduate Medical Education [ACGME] and the American Board of Preventive Medicine [ABPM] board certification requirements), current residency curriculums, and other information regarding current and former aerospace medicine training programs. Informational interviews with 43 SMEs, primarily current and former NASA flight surgeons, were used to develop findings and recommendations on aerospace medicine training and core competencies. Data on the interviewee's background and experience was collected and cataloged to aid in data analysis (Figure 2).

Interviewee responses were analyzed using an internally developed coding scheme to identify common themes, skills, or components of the knowledge base, which was then integrated with knowledge from the literature review to create an initial list of core competencies (Figure 3). This initial list was re-evaluated by SMEs during a closed-door roundtable discussion and additional individual interviews to inform a second iteration of aerospace medicine core competencies. The skills and knowledge identified were categorized hierarchically into three levels of core competencies. The four first-level core competencies identify the overarching themes supported by second-level competencies, which are general skills and knowledge areas. Below are third-level competencies, which are examples of specific skills or abilities needed to carry out the responsibilities associated with providing care as an aerospace medicine practitioner. Additionally, each third level skill or knowledge area was categorized using indicators of the level of expertise required and applicability to specific settings (see Figure 1 above).

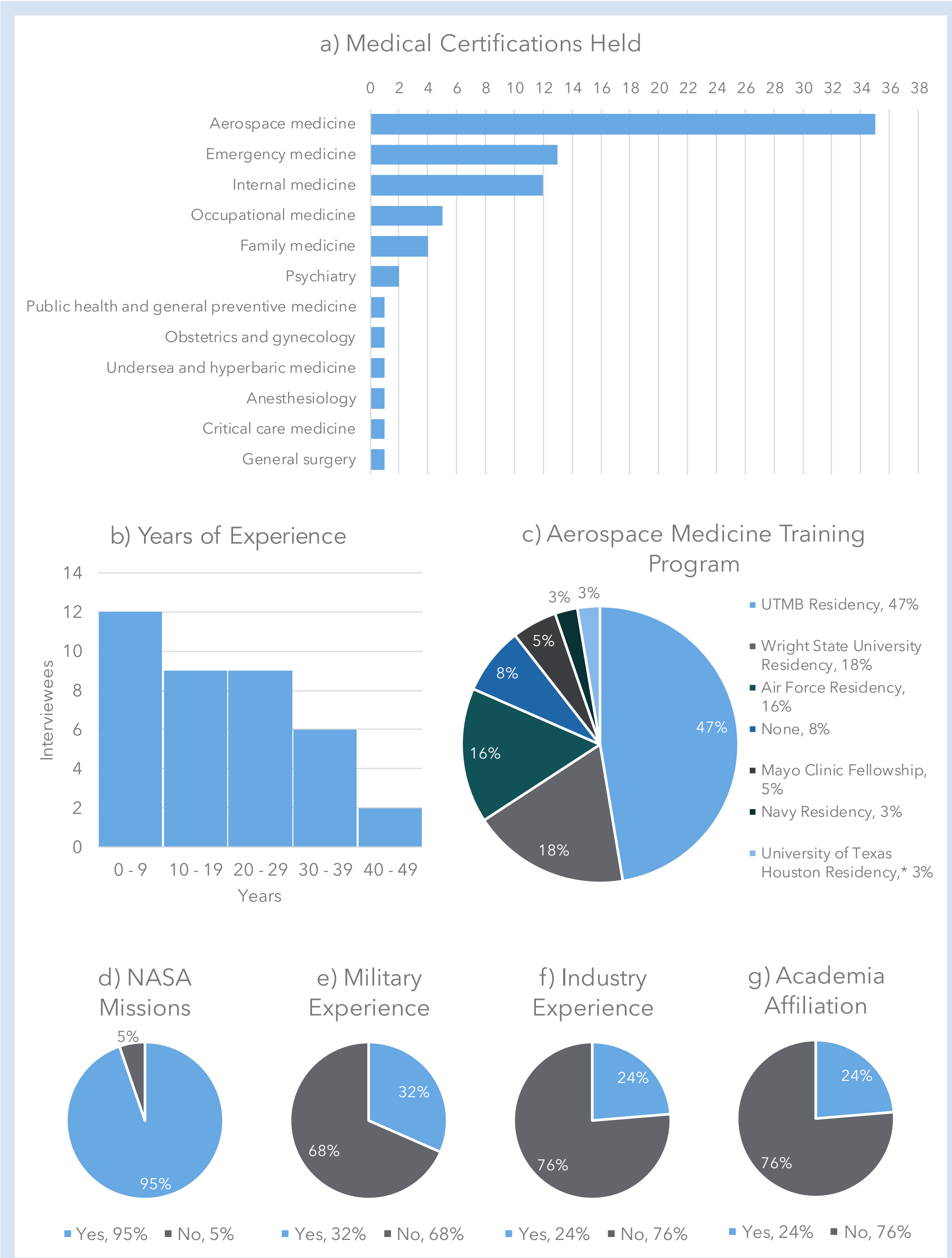

Figure 2. Key features of aerospace medicine providers interviewed. a) Medical board certifications held (categories not exclusive). b) Years of experience in aerospace medicine. c) Aerospace medicine training program completed. d) Experience as a flight surgeon on NASA missions. e) Experience as a military aerospace medicine provider. f) Experience as an industry aerospace medicine provider. g) Academic affiliation with training programs. *Residency ultimately not approved. Image: Potomac Institute for Policy Studies.

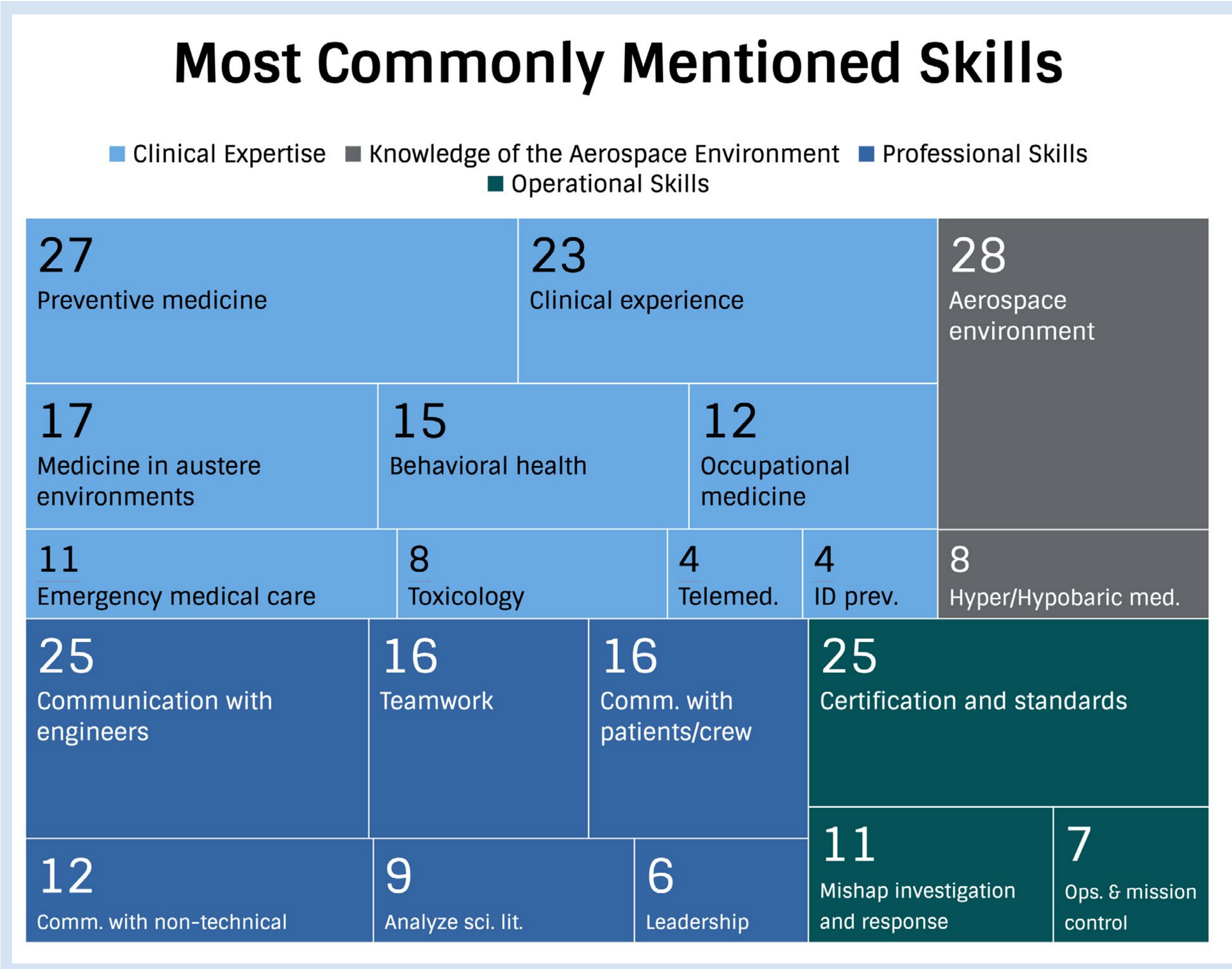

Figure 3. Skills and knowledge areas most commonly mentioned in SME interviews. Numbers given in each box represent the number of interviewees who described that skill or knowledge area as an important component of the practice of aerospace medicine. Image: Potomac Institute for Policy Studies.

ENDNOTES

1 *History*. (n.d.). Aerospace Medical Association. https://www.asma.org/about-asma/history

2 *Aerospace Medicine*. (n.d.). Aerospace Medical Association. https://www.asma.org/about-asma/careers/aerospace-medicine

3 *Aerospace Medical Certification Standards*. (2024, May 16). Office of the Chief Medical Officer (OCHMO)/NASA. https://www.nasa.gov/organizations/ochmo/aerospace-medical-certification-standard/

4 *Residency programs & related courses*. (n.d.). Aerospace Medical Association. https://www.asma.org/about-asma/careers/aerospace-medicine/residency-programs-related-courses

5 Interview #22, personal communication, September 8, 2023.

6 Government Accountability Office. (2018, March). Physician workforce: HHS needs better information to comprehensively evaluate graduate medical education funding (GAO-18-240). https://www.gao.gov/assets/gao-18-240.pdf

7 Interview #11, personal communication, August 18, 2023.

8. 5 Hazards of Human Spaceflight. (2024, January 03). NASA. https://www.nasa.gov/hrp/hazards

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