Medical Policy Development for Human Spaceflight at NASA: An Evolution

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Codification of medical policy for the National Aeronautics and Space Administration (NASA) did not occur until 1977. Policy development was based on NASA's human spaceflight efforts from 1958, and the need to support the operational aspects of the upcoming Space Shuttle Program as well as other future activities. In 1958, the Space Task Group (STG), a part of the National Advisory Committee on Aeronautics (NACA), became the focal point for astronaut selection, medical support, and instrumentation development in support of Project Mercury. NACA transitioned into NASA in 1958. The STG moved to Houston, TX, in 1961 and became the Manned Spacecraft Center. During these early years, medical support for astronaut selection and healthcare was provided through arrangements with the U.S. military, specifically the United States Air Force, which had the largest group of subject matter experts in aerospace medicine. Through most of the 1960s, the military worked very closely with NASA in developing the foundations of bioastronautics and space medicine. This work was complemented by select individuals from outside the government. From 1958 to 1977, there was no standard approach to medical policy formulation within NASA. During this time, it was individualized and subjected to political pressures. This manuscript documents the evolution of medical policy in the NASA, and provides a historical account of the individuals, processes, and needs to develop policy.

Keywords: Spaceflight, medical policy, history, space medicine.

FROM 1915 – 1958, the National Advisory Committee on Aeronautics (NACA) was the organization in the United States that focused on aviation and, eventually, on space. On July 29, 1958, President Eisenhower signed the National Aeronautics and Space Act, which established the National Aeronautics and Space Administration (NASA). On October 1, 1958, NASA assumed all of NACA's activities and its 8000 employees (4,10). The Space Task Group (STG) was established on November 5, 1958 under the direction of Robert Gilruth. Within months, NASA moved forward with Project Mercury (10), including selection of the first American astronauts.

At this time, NASA did not have a program for selecting individuals to be astronauts or developing and monitoring astronaut health. NASA did not adopt or institutionalize a medical policy development process, including standards for medical selection and retention of astronauts, until the late 1970s. Instead, NASA relied on the U.S. Air Force (USAF), which had significant aerospace medicine experience. An agreement between NASA and the Department of Defense to develop a Bioastronautics Program was established to support the new space agency's efforts (10,13). Military aerospace medicine experts were assigned to the STG, initially part of NACA and then with NASA. This collection of experts included representatives from the U.S. Air Force (Dr. Stanley White), the U.S. Army (Dr. William Augerson), and the U.S. Navy (Dr. Robert Voas).

This group began to conduct extensive medical evaluations in preparation for selection and eventually flight. These evaluations were conducted at military installations such as Wright-Patterson Air Force Base in Dayton, OH, and the Lovelace Foundation for Medical Research and Education in Albuquerque, NM. Prior to this effort, testing and evaluation throughout the 1950s had been done on mice, dogs, and monkeys (11).

Medical standards for crew selection were guided by the U.S. military with input from the research community, pioneering subject matter experts, and leaders in aerospace medicine like Dr. Randolph Lovelace (10,12). In addition, selection procedures were mostly experimental for the first several groups of astronauts from the U.S. Air Force, U.S. Army, and U.S. Navy (3). These standards and guidelines were used to support selection for Projects Mercury, Gemini, Apollo, Skylab, and Apollo-Soyuz. The medical support during this time period was primarily focused on getting the astronauts ready for flight and developing an understanding of how spaceflight affected them during flight and postflight.

NASA's Foundation of Space Medicine Approach

In the early 1960s, NASA created a Space Medicine function at NASA Headquarters under the direction of USAF General Charles H. Roadman. Standards for aeromedical practice were adopted to support the development of medical testing and medical kits for incorporation into the Mercury, Gemini, and Apollo spacecraft through the STG (15). Early work was supported by subject matter experts from panels such as the Life Sciences Panel and the Ad Hoc Working Group on Bioinstrumentation.

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A Bioastronautics Agreement with the USAF helped solidify the pooling of resources to help NASA build its fledgling space medicine function (9,10,12). In 1961, the STG was relocated from Langley, VA, to Houston, TX, and became known as the Manned Spacecraft Center (MSC) (now Lyndon B. Johnson Space Center, JSC). Here the expertise of Drs. W. Randolph Lovelace, Stanley White, William Douglas, Robert Voas, William Augerson, Charles Berry, and others, all on loan from the U.S. military, helped push the foundation of space medicine forward for NASA and for the discipline of space medicine itself.

The disciplines of Aerospace Medicine and Life Sciences shared a common stage at the beginning of the human spaceflight program at NASA. There was often conflict between NASA's extramural community, i.e., the Kety Committee* and the Special Committee on Life Sciences, and different NASA field centers. Furthermore, there was an ongoing conflict between NASA and the USAF and Congress with regard to expertise and duplications of effort.

NASA's extramural community and the USAF were critical of NASA management and the organization of its Life Sciences and Space Medicine functions. In 1964, NASA Deputy Administrator Robert C. Seamans, Jr. sought to alleviate the some of the challenges by establishing the Life Sciences Director's Group (9,10). This was to provide an advisory role for Life Sciences within NASA and to appease the external advisory committee's observation that Life Sciences and Aerospace Medicine functions were not coalesced under one program office. It functioned from 1964–1968 with little authority. Life Sciences functions at the NASA MSC and Ames Research Center (ARC) were conducted with limited interaction from the NASA Headquarters Life Science management. In 1968, NASA Associate Administrator Homer Newell replaced this Group with the NASA Space Biology and Aerospace Medicine Board. During this decade (1960–1970), NASA ARC and the NASA MSC were on different tracks and were often seen as autonomous—a trait carried over from the NACA STG days, and which in some ways still exists today.

Policy Development

Space medicine in the 1960s and 1970s was successful in identifying and validating, through limited research, the medical challenges of human spaceflight and the mission of getting to the Moon. The knowledge gained with each successive mission provided valuable insight (5,6). Medical support in the early missions was primarily to support operational medicine. Due to space constraints and limitations in the space capsules, very little was done in the way of research during flight. As the cabin became larger, in-flight research opportunities increased. Nevertheless, significant knowledge was gained from pre- and postflight research.

Many issues related to crew selection and the lack of sufficient evidence in decision making regarding crew health had been observed. While the cadre of astronauts selected to date had been subjected to a wide variety of testing, there was no consistent approach or standard protocols, and there were often adversarial relationships. Medical decisions were based on understanding of each individual astronaut and not on a standardized approach using evidence-based medicine. The selection criteria which NASA used were based on those used for military pilots (11). Research protocols developed by the Lovelace Foundation and the Mayo Clinic were utilized, although these were largely untested.

In 1977, NASA began to finalize plans for the Space Shuttle Program. There was a need to develop selection standards based on a new kind of astronaut; one who was not categorized as a military pilot, but one who would conduct research tasks during spaceflight operations. These types of astronaut came to be known as Mission Specialists and Payload Specialists. In addition, medical evaluation, certification, and decision making had not been standardized. There was a need to develop an approach that eliminated inconsistencies and establish "standard" procedures and processes.

At JSC, Dr. Arnauld Nicogossian began to develop the concept of a medical policy board to ensure that there would be a practical way to address crew health and performance on a clinical and scientific basis. He also began to draft new selection standards. In 1977, Dr. Nicogossian joined Dr. Rufus Hessberg and the Life Sciences effort at NASA Headquarters under the direction of Dr. David Winter. The medical standards and policy boards were coordinated by Dr. Nicogossian at NASA Headquarters in cooperation with the Office of Personnel Management and the Office of Management and Budget to ensure that an occupational health model was followed and that the proper federal process was adhered to. Dr. Hessberg, the NASA Headquarters Chief of the Space Medicine Division, oversaw and assisted with the process (Nicogossian A. Personal communication; March 14, 2011). To evaluate the efficacy of these standards, a full simulation was conducted on 20 subjects. Each individual completed the selection process with no issues and the new guidelines were approved for use (Pool SL. Personal communication; Feb. 1, 2011).

In addition to selection standards, there was a need for a governing board. The NASA Space Medicine Board (SMB) was created to function as the entity that would review medically related issues and crew selection and then decide on a course of action. The NASA Space Medicine Policy Board (SPMB) was created as a higher level authority board that would develop and maintain Agency-wide medical policy. The philosophy of NASA senior medical personnel at this time was influenced by

*An ad hoc Bioscience Advisory Committee to study the capability in space-oriented life-science research and development to outline the scope of current and future problem areas in the space bioscience field, and to recommend the future role of NASA in a bioscience program. Composed of leading scientists, this committee was under the chairmanship of Dr. Seymour S. Kety, Director of the Clinical Science Laboratory of the National Institutes of Health, and known as the Kety Committee.

the Space Shuttle Program and the experiences of the past two decades of human spaceflight activities.

Two specific issues helped shape the need for a formal medical policy board. The first issue was intermittent atrial fibrillation affecting astronaut Deke Slayton and his eventual flight assignment to the Apollo Soyuz Test Program. The other was that throughout human spaceflight there has been disagreement regarding physical exercise and the overall impact of in-flight exercise on the musculoskeletal system. Different protocols and timelines for annual crew certifications were employed. Crewmembers assigned to Apollo or Skylab missions performed exercise in-flight based on research needs (5,6,14). Crews not assigned to flight opportunities participated in exercise that was clinically driven. This paradigm did not permit adequate comparison of data and, therefore, a standardized in-flight countermeasure prescription could not be written (Nicogossian A. Personal communication; March 14, 2011). Operational (flight) medicine and researchers were often in disagreement as to how best measure it and what the appropriate standards were.

Development of Selection Standards and NASA Medical Policy Structure

As indicated above, the early selection standards for Mercury, Gemini, Apollo, Skylab, and Apollo-Soyuz were based on those used by the military (11). Slight changes occurred with each astronaut selection. It was the development of the Space Shuttle Program that laid the foundation and established the need for NASA to develop and certify selection standards to meet this new era of human spaceflight. These same standards were reviewed and updated as necessary to support the Shuttle/Mir program and the International Space Station (ISS). Beginning with the Space Shuttle Program, approval of these standards was the responsibility of the SMPB.

Tempered by need and experience, Space Medicine and Life Sciences personnel at NASA Headquarters and JSC developed the appropriate documentation. This documentation was reviewed by a group of intramural and extramural aviation and space medicine experts (see **Table I**).

The outcome of this effort was a baseline NASA Management Instruction (NMI) document entitled NMI 1152.59 – Space Medicine Boards in Support of Space Crew Qualification for Space Flight. This NMI became effective on July 8, 1977. This document established two boards, the Headquarters-level SMPB and the JSC SMB. The document outlined the function of the boards to medically qualify astronauts for spaceflight. **Table II** lists the chronology of medical policy authority documents, which have been updated on a regular basis or as needed.

Codification

NASA Space Medicine, led by Dr. Nicogossian for more than 25 years under successive administrators, established and utilized a management structure complete with documentation that granted authority and responsibility for various functions. Documentation structure and nomenclature were modified and updated as NASA evolved. They evolved from NASA Management Issues to NASA Management Instructions (NMI) and eventually to NASA Policy Charters (NPCs), NASA Policy Directives (NPDs), and NASA Procedures and Guidelines. Although documentation nomenclature and process changed, the SPMB structure and function remained consistent and supported by all NASA administrators. All documents flow from the original and amended Space Act of 1958, 42 USC 2473 (c)(1), Section 203 (c)(1).

Astronaut healthcare is authorized through additional documentation, including NPD 8900.1A Operational Medical Responsibility for the Space Transportation System (now known as Astronaut Medical and Dental Observation Study and Care Program), which was initially approved in early 1981, prior to the first Space Shuttle launch. It has evolved and has been updated periodically, usually at a frequency of 4 – 5 years. These documents have laid out the responsibility, requirements, and systems for care of astronauts during all phases of human spaceflight.

Purpose of Medical Policy

The authority that provides responsibility for selecting astronauts and supporting medical care with all

TABLE I. MEMBERS OF THE INITIAL MEDICAL POLICY DEVELOPMENT WORKING GROUP.

Name	Title	Organization
Arnauld Nicogossian, M.D.	Manager, Aerospace Medicine	NASA HQ, Aerospace Medicine, Life Sciences Division (LSD), Office of Space Sciences and Applications (OSSA)
Rufus Hessberg, M.D.	Chief, Space Medicine	NASA HQ, Aerospace Medicine, LSD OSSA
Frank Austin, M.D.	Director of Environmental Life Science	Office, Under Secretary of Defense for Research and Engineering
Homer L. 'Rick' Reighard, M.D.	Federal Air Surgeon	Federal Aviation Administration (FAA)
George E. Schafer, M.D.	Surgeon General	USAF, Office of the Surgeon General
Robert Moser, M.D.	Advisor	American College of Physicians
Gerald Soffen, Ph.D.	Director, Life Sciences	NASA HQ, OSSA

LSD = Life Sciences Division; OSSA = Office of Space Sciences and Applications; USAF = United States Air Force; FAA = Federal Aviation Administration.

TABLE II. MEDICAL POLICY AUTHORITY DOCUMENTS (NASA HEADQUARTERS).

Year	Document Number	Document Name	Responsible HQ Office
Jun 24, 1965 Sep 14, 1966	NMI 1152 NMI 1152.18A	NASA Life Sciences Directors Group	OART/OMSF/OSS
July 8, 1977	NMI 1152.59	Space Medicine Boards in Support of Space Crew Qualification for Spaceflight	SB/Office of Life Sciences
Jan 18, 1980	NMI 1152.59A	Space Medicine Boards in Support of Space Crew Qualification for Spaceflight	SB/ Life Sciences Division
Apr 4, 1984	NMI 1152.59B	NASA Medical Boards in Support of Crew Qualifications for Spacecraft Operations	EB/Life Sciences Division
Oct 2, 1989	NMI 1152.59C	NASA Medical Boards in Support of Crew Qualifications for Spacecraft and Aircraft Operations	EB/Life Sciences Division
Dec 12, 1991	NMI 1152.59D	NASA Medical Boards in Support of Crew Qualifications for Spacecraft and Aircraft Operations	SB/Life Sciences Division
June 29, 1993	NMI 1152.59E	NASA Medical Boards in Support of Space Flight Operations	M/Office of Space Flight
Dec 4, 1998	NPC 1152.59F	NASA Medical Boards in Support of Space Flight Operations	M/Office of Space Flight
Jul 1998	NPC 1152.4	NASA Medical Policy Boards in Support of Space Flight Operations	Code U
May 20, 2003	NPD 8900.5	Review and Approval of Human Health Related Research Requirements and Biomedical Research Deliverables	Code AM - Office of the Chief Health and Medical Officer (OCHMO)
May 16, 2006	NPD 8900.5A	NASA Health and Medical Policy for Human Space Exploration	Code QA – OCHMO
Jul 25, 2007	NC 1000-12	NASA Medical Policy Board and ASM Board	Code QA – OCHMO
Dec 17, 2009	NC 1000-26	NASA Medical Policy Board and ASM Board	Code QA – OCHMO

NPC or NC = NASA Policy Charter; NMI = NASA Management Instruction; NPD = NASA Policy Directive.
Note: Each successive document replaced the previous.

phases of spaceflight is stated in NASA documentation. As outlined above, there is a long lineage of documentation that supports the overall mission of ensuring the health of the men and women who fly in space. The need for medical policy as outlined above was to support NASA's medical efforts during spaceflight activities. The intent was to create the necessary structure for reviewing all issues that pertained to crew healthcare at both an operational level (NASA JSC) and at an Agency level (NASA Headquarters).

The purpose of policy in any organization is to provide guidelines for determining how things are accomplished. The NASA SMPB function is to establish and set forth the policies necessary to establish the appropriate requirements, standards, and systems to ensure the selection of new astronauts, resolve medical disputes, and provide for astronaut healthcare in support of NASA missions.

The current NPD 8900.5A states that it is NASA policy to:

1. Provide a healthy and safe environment for crewmembers to enable successful human space exploration;
2. Provide health and medical care systems for crewmembers for all mission phases – preflight, flight and postflight (health is defined as encompassing physiological, psychological, and dental well-being. Medical refers to the treatment of illness and injury);
3. Update crewmember health and medical services based on best supporting evidence and current standards of medical practice, lessons learned, risk management, and expert recommendations;
4. Design initial and recurrent medical training for crewmembers, consistent with mission requirements, and commensurate with available resources and priorities; and
5. Establish spaceflight health and medical standards that address:
   a. Health and medical screening, evaluation, and certification (including selection and retention standards);
   b. Health and medical diagnosis, intervention, and care (including management and training);
   c. Health maintenance, preventive programs and countermeasures (including permissible exposure limits, permissible outcome limits, and fitness for duty standards);
   d. Habitability and environmental health guidelines and standards as appropriate (These standards are documented in NASA-STD-3001, Volume 1: NASA Space Flight Human System Standard - Crew Health and NASA-STD-3001 Volume 2: NASA Space Flight Human System Standard - Human Factors, Habitability, and Environmental Health); and
   e. Sponsor health and clinical research to enable human space exploration.

Evolution of the Boards and Their Functions

The SMPB became known as the MPB in 1989. This board was comprised of senior physicians from various NASA Centers (ARC, JSC, Kennedy Space Center, etc.), a physician member of the astronaut corps, and physicians from other federal agencies, including the Federal Aviation Administration and the National Institutes of Health. The chair of the MPB has been held by Dr. Nicogossian (1978–2002) and Dr. Richard S. Williams (2002–2011). An executive secretary coordinates the MPB meetings, including agendas, all correspondence, maintenance of the policies, and preparation of minutes from each meeting.

The MPB Chair works closely with the JSC SMB (now called the Aerospace Medicine Board [AMB]) to resolve any medical issues related to crew health or selection. The MPB Chair rarely intercedes on an AMB decision.

The process of medical policy can result from a number of inputs, such as mission definition, a medical event, new knowledge from research outcomes, or input

from an operational issue. An issue, challenge or opportunity is brought before the MPB for consideration. The MPB reviews the pertinent information and supporting documentation and develops a policy. Once this policy is approved by the MPB, it is adopted and communicated with the operational elements at JSC.

The MPB was a result of the post Apollo Program. It was fully functional prior the start of the Space Shuttle Program and has remained viable through each of NASA's human spaceflight programs since 1977. As NASA worked closely with its ISS partners, Dr. Nicogossian established a similar medical structure to support ISS operations. This included the Multilateral Space Medicine Board and the Multilateral Medical Policy Board. These boards and the MPB have been very successful in supporting crew selections for the Space Shuttle missions and the missions to the ISS (7,8).

Summary

During the first two decades, NASA's human spaceflight program was focused on getting into space and landing on the moon. While this was the major thrust, there was minimal time and resources to conduct a broadly-scoped research program on humans in space. Once the Space Shuttle Program started and the number of flight opportunities increased, there was a need to develop policies and selection criteria for new astronauts, and evaluate the longitudinal impact of spaceflight on those who have flown in space, all through evidence-based medicine (2). The future of human spaceflight required a medical policy function.

It is likely that the same structure would be in place to support whatever mission NASA is tasked with doing. Over the past decade or so, there has been discussion and plans to send humans back to the Moon, to Mars, or to an asteroid. Each of these missions will require unique medical capabilities, unique crew composition, and strong medical policy (1). The foundation of the MPB has resulted in processes that will serve human spaceflight into the future, whether it is unique to NASA or is multicultural in nature. The MPB will serve as a model for commercial spaceflight activities as well.

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