

CHAPTER 6

FLIGHT CREW HEALTH STABILIZATION PROGRAM

by

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Introduction

When mission durations were increased during the Gemini Program, the possibility that an infectious disease occurrence would adversely affect mission success also increased. The problem did not seem one of major proportions for Project Mercury, because the risk of developing and manifesting a disease during such short duration flights was judged to be extremely low. Even so, crewmember activities were somewhat restricted in terms of contact with persons not directly involved in flight activities. While some cold and influenza symptoms were noted in crewmembers during the preflight period, no inflight illnesses occurred during Project Mercury.

When the training phase of the Gemini Program began, medical personnel were still providing active support for the Mercury flights. Little attention could, therefore, be given to implementing any program of strict isolation of Gemini astronauts during the prelaunch period. Medical personnel were successful in obtaining some reduction in the number of persons with whom the crewmembers had personal contact and were successful, to a limited extent, in having the flight crewmembers live in special quarters at the launch site. During the prelaunch period, access to these living quarters was closely controlled. While no direct illness erupted in flight, most Gemini crews experienced some preflight illness including colds, influenza, Beta-hemolytic streptococcus infections, and mumps.

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During the early development of the Apollo Program, steps were taken by medical personnel to document and implement a preventive medicine program to decrease the risk of illness during the prelaunch and flight periods. Because of early operational problems, no successful program could be developed for the Apollo 7 crewmembers. Perhaps in part as a consequence of this, two Apollo 7 crewmembers developed upper respiratory tract infections during the prelaunch period. These infections were successfully treated prior to launch. However, all crewmembers fell ill during the flight with symptoms which continued into the postflight period.

As a result of the Apollo 7 experience, a medical plan was developed for application to the prime and backup crews of future missions. The intent of the plan was to minimize exposure of crewmen to infectious diseases during the two-week period prior to launch for the crews of Apollo 8, 9, and 10, and during the three-week period preceding the Apollo 11 lunar landing launch. The program was designed to ensure optimal immunity, to reduce person-to-person contact, and to ensure rapid diagnosis and treatment of any diseases that might occur prior to flight. However, as had been the case in the Gemini Program, the Apollo training schedules had already been developed at the time a health stabilization program was conceived, and flight crewmembers, in seeking to maximize their training time and familiarity with spacecraft hardware, ran the risk of incurring greater than desirable disease exposure.

During the Apollo 8 preflight period, all crewmembers suffered viral gastroenteritis. Treatment appeared to be successful, and the spacecraft was launched on schedule. However, viral gastroenteritis reoccurred in the Commander in flight. Before the flight, crewmembers had attended a dinner at the White House, where, it later became known, several guests had had symptoms of influenza. While no rigid health stabilization program was to be established until the time of the Apollo 14 mission, increasing efforts in that direction commenced after the Apollo 8 illness episode.

The emphasis of the post-Apollo 8 health stabilization efforts involved constraint of crewmember activities that could impose the risk of disease exposure when such activities were not directly related to flight preparation. The residence of the crewmembers was limited to the crew quarters at the launch site, and control and screening were provided for personnel who had access to the quarters and conference rooms. The use of laminar airflow rooms for preflight press conferences was initiated in advance of the Apollo 11 mission. A proposed Presidential dinner prior to the Apollo 11 mission was cancelled because of the potential risk to the health of the crew. Activities of the crewmembers continued to be monitored closely. Despite these efforts, one of the primary Apollo 13 crewmembers was exposed to rubella by a backup crewman. Laboratory studies indicated that the Command Module Pilot alone had no immunity to the disease and he had to be replaced by one of the backup crew.

The Apollo 13 episode showed beyond question that the need existed for implementation of a meticulously conceived and strictly enforced program for minimizing and, hopefully, preventing exposure of flight crewmembers to infectious diseases during the prelaunch period. Such a program was developed and conceived for the Apollo 14 and subsequent missions. The program became known as the Flight Crew Health Stabilization Program.

Purpose

The purpose of the Flight Crew Health Stabilization Program finally conceived and implemented was to minimize or eliminate the possibility of adverse alterations in the health of flight crews during the immediate preflight, flight, and postflight periods. The elements of the program are indicated in figure 1. Each of these warrants discussion in terms of the direction taken for implementation in the Apollo Program and for subsequent missions.

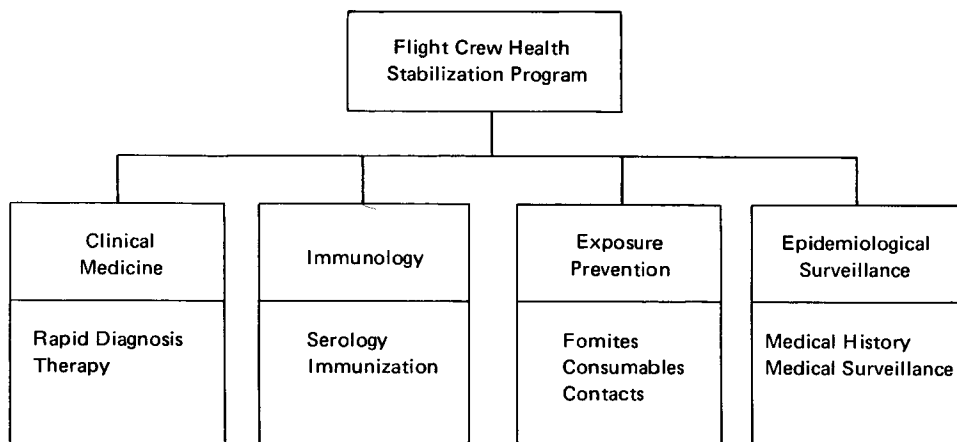


Figure 1. Elements of the Flight Crew Health Stabilization Program.

Clinical Medicine

Because it is critical that all astronauts be maintained in good health, the Government provided a clinical medicine program for Apollo crewmembers and their families and continues to do so for the astronaut corps. This health program is a continual one. It is initiated immediately upon selection of flight crewmembers and continues as long as astronauts are on flight status. The program provides both routine and emergency physical examinations. Rapid diagnosis and prompt effective treatment of any disease event in crewmembers and their families are ensured by complete virological, bacteriological, immunological, serological, and biochemical studies at the National Aeronautics and Space Administration's Lyndon B. Johnson Space Center. (Additional detail concerning the program is given in Chapter 2 of this section.)

Immunology

Ideally, one would desire to immunize crewmembers and their families against all disease agents to preclude the expression of disease symptoms. However, the number of diseases for which there are satisfactory immunizations is extremely limited. Indeed, immunizations are not available for the illnesses most likely to occur – viral and bacterial infections of the upper respiratory and gastrointestinal tracts. The immunizations listed in

table 1 were those administered in conjunction with Apollo missions. These were selected after careful review of all known immunizations by NASA medical personnel and a microbiology advisory committee of the National Academy of Sciences. Other immunizations were excluded on the following bases: (1) questionable effectiveness; (2) traumatic side reactions; and (3) low probability of disease agent exposure. Serological tests were conducted to determine immunity levels prior to immunizations. Tuberculin skin tests were given and serological tests were performed for tetanus, syphilis, typhoid, mumps, polio, rubella, rubeola, and yellow fever.

Table 1
Apollo Program Immunization Requirements^a

Disease	Required Immunization of Astronaut	Required Immunization of Family Members of Astronaut
Diphtheria	Yes	Yes
Pertussis	No	Yes
Tetanus	Yes	Yes
Typhoid	Yes	No
Influenza	Yes	No
Mumps	Yes ^b	Yes
Poliomyelitis	Yes	Yes
Rubella	Yes ^b	Yes
Rubeola	Yes ^b	Yes
Smallpox	Yes	Yes
Yellow fever	Yes	No
Other	(c)	(c)

^aSchedule recommended by personnel of the USPHS and of the American Public Health Association.

^bImmunization if no serologic response was obtained.

^cOnly as indicated for travel to endemic areas.

Exposure Prevention

Disease exposure prevention was the most important aspect of the Apollo preventive medicine program. If exposure to infectious diseases had not been minimized or eliminated, the program would have been unsuccessful regardless of the effectiveness of all other aspects combined. Diseases can be transmitted by fomites (contaminated inanimate objects), contaminated consumables (air, food, water, etc.), and personal contacts. Fomites probably represented the least important source of infectious diseases. Nevertheless, the precaution of using separate headsets, microphones, and so forth, for crewmembers was observed. Contaminated consumables posed a greater danger. To

prevent transmission of an infectious disease through the air, a closely controlled living environment was provided during the prelaunch period.

All areas in which crewmembers resided or worked were equipped with ultra-high efficiency bacterial filters in all air supply ducts. This precluded exposure to microbial agents from adjacent non-medically controlled areas and individuals. Air conditioning systems were also balanced to provide air pressure in those areas inhabited by crewmembers, as compared with areas outside. Air leakage around windows, doors, floors, walls, and ceilings was directed outward rather than inward toward crewmembers.

The food supply consumed by flight crewmembers was a source of potentially infectious microorganisms. As a precautionary measure, no set or publicized pattern of food procurement was established. Crew quarters food procurement was supervised by members of the medical team. Portions of each lot of food were subjected to microbiological evaluations and all food preparation areas were inspected daily for cleanliness and maintenance of satisfactory sanitary conditions. Drinking water sources were limited to drinking fountains provided in the quarters and working spaces. Water samples were taken daily from all areas visited by the crewmembers and subjected to microbiological evaluations.

By far the most important means of preventing crew exposure to infectious diseases was to minimize exposure to personal contacts during the critical preflight period. The areas which could be visited by crewmembers were strictly limited and the number of individuals allowed contact with the crewmembers was reduced to slightly over one hundred people with mission-related responsibilities. A medical surveillance program of primary contacts was conducted to ensure that those people who did have contact with the flight crewmembers represented a low probability of disease transmission. Additionally, crewmembers were isolated from potential carriers, such as transient populations (launch site visitors), high incidence groups (children), and uncontrolled contacts (maintenance and other personnel about whom no medical information was known). Launch site visitors came from all over the United States and from many foreign nations and brought with them a flora that differed significantly from that normally experienced by the astronauts. Children are the most common carriers and transmitters of upper respiratory and gastrointestinal infections. Astronauts were therefore isolated for 21 days prior to flight even from their own children. The need for this measure was borne out by epidemiological data obtained during initial implementation of the health stabilization program.

Several options were available to minimize crew exposure to infectious agents. Building facilities to house crews and primary contacts for the prelaunch period or modifying existing ones to this end would have been effective approaches, but they were economically prohibitive. The more economical solution provided for strict isolation of flight crewmembers, both prime and backup, in crew quarters and limiting their contacts to medically approved individuals only. These latter individuals were permitted to maintain their residence at home. However, their health status was continually monitored to minimize the possibility of their exposing flight crewmembers to any infectious disease agent. This monitoring of primary contacts resulted in the epidemiological surveillance program.

Epidemiological Surveillance

The medical surveillance program, initiated three months prior to launch, began with the taking of medical histories and other critical information from each primary contact. Each was then subjected to an extensive physical examination approximately 60 days prior to launch, and microbiological samples were obtained to identify carriers. Based on this information, certain individuals were medically approved for access to flight crewmembers during the 21-day prelaunch period.

Each primary contact and all his family members were subjected to medical surveillance during the F-21 (flight day minus 21 days) period. Primary contacts were instructed to report to the medical examination facility whenever they or any of their family became ill or had been exposed to any infectious diseases. Reports of illness events were also obtained from all schools attended by primary contacts' or astronauts' children. Daily reports were solicited from each school of interest concerning the total number of absences, including absences of the children of any crewmember or primary contact. Additional daily reports were obtained from public health authorities in the launch site area to determine trends and incidence of specific disease events within the population where primary contacts may have had exposure. A computerized data processing system was developed to maintain complete and up-to-date records on all crewmembers, primary contacts, and their families. The system linked the medical analyses laboratories at the NASA Lyndon B. Johnson Space Center in Houston, Texas, with the Medical Surveillance Office at the Kennedy Space Center, Florida. Medical information on any individual was immediately available by this system.

Results

The success of the Flight Crew Health Stabilization Program implemented in support of the Apollo 14 through 17 missions was evidenced by absence of preflight, inflight, and postflight illnesses. A comparison of the illness incidents for astronauts, primary contacts, and their families, and for the control group, their spouses and children for each mission is tabulated in table 2. A comparison of the type of illness event occurring in the primary contacts and dependent group is given in table 3. Monitoring the health of primary-contact children proved to be valuable because in approximately 30 percent of the cases of illness in primary contacts, similar illnesses had occurred previously in one or more of the family members. The most common type of illness reported was upper respiratory tract infection.

Summary and Conclusions

The Flight Crew Health Stabilization Program, developed to minimize exposure of flight crewmembers to infectious microorganisms in the prelaunch period, had three basic aspects. These were:

1. Control of locations to which flight crewmembers had access during the three-week period before launch.

Table 2
 Apollo Flight Crew Health Stabilization Program Comparison
 of Illness Incidence for the Apollo 14 to 17 Missions

Population	Mission Number											
	14 ^a		15 ^b		16 ^c		17 ^d					
	Number of Persons	Percentage of Illness Incidence	Number of Persons	Percentage of Illness Incidence	Number of Persons	Percentage of Illness Incidence	Number of Persons	Percentage of Illness Incidence				
Astronauts (prime & backup)	12	0	15	0	15	0	13	0				
Primary contacts	161	22	151	13	180	35	176	28				
Spouses	130	6	132	1	139	15	147	10				
Children	242	56	241	8	226	28	263	26				
Control group	—	—	145	10	149	32	—	—				
Spouses	—	—	127	5	121	12	—	—				
Children	—	—	230	5	241	18	—	—				

^aSurveillance period was from December 7, 1970 to February 9, 1971.

^bSurveillance period was from June 11, 1971 to August 7, 1971.

^cSurveillance period was from February 28, 1972 to April 27, 1972.

^dSurveillance period was from October 16, 1972 to December 19, 1972.

2. Control of the number of personal contacts of the astronauts during the three-week prelaunch period.
3. Careful monitoring of the health of individuals required to be in contact with flight crewmembers.

Table 3
Apollo Flight Crew Health Stabilization Program Characterization
of Illnesses for the Apollo 14 to 17 Missions*
 (values are number of illnesses)

Illness	Mission Number			
	14	15	16	17
Upper respiratory infections	156	32	89	77
Gastrointestinal infections	12	1	28	24
Ear infections	7	3	5	2
Chicken pox	3	0	3	0
Pneumonia	3	1	1	1
Measles	0	1	0	0
Primary contacts and dependents under surveillance	575	569	590	644

*Primary contacts and dependents only.

In summary, the Flight Crew Health Stabilization Program was an unequivocal success. No crewmember illness was reported for the missions for which the program was in effect. Statistics recorded for prior Apollo missions indicated that 57 percent of the prime crewmembers experienced some illness during the 21 days prior to launch, as well as illness events inflight and postflight.

The importance of a health stabilization program was clearly demonstrated by the Apollo experience. The importance of such a program will become more critical for manned missions of longer durations, and it is anticipated that a stricter isolation program may be necessary to prevent the potential threat of infectious disease and compromise of mission success.

References

- Downs, T.D.; Eitzen, H.E.; and Labarthe, D.R.: Apollo 16 Surveillance Report (NAS 9-12640). University of Texas School of Public Health (Houston, Texas), June 1, 1972.
- Eitzen, H.E.: Apollo 15 Final Surveillance Report (NAS 9-11384). University of Texas School of Public Health (Houston, Texas), September 1, 1971.
- Eitzen, H.E.: Apollo 14 Flight Crew Health Stabilization Program Analysis (NAS 9-11384). University of Texas School of Public Health (Houston, Texas), March 1, 1971.

McCollum, G.W.: Apollo 17 Flight Crew Health Stabilization Program Mission Report. NASA (Houston, Texas), January 17, 1973.

Wooley, B.C.: Apollo Experience Report – Protection of Life and Health. NASA TN D-6856, 1972.