



Health Stabilization Program (HSP)

OCHMO-TB-006
Rev D



Relevant Technical Requirements

NASA-STD-3001 Volume 1, Rev B
[V1 3002] Pre-Mission Preventive Health Care
[V1 3012] Terrestrial Launch/Landing Medical Support

Executive Summary

A comprehensive Health Stabilization Program (HSP) is needed for all spaceflight missions to reduce infections pre-flight and prevent subsequent symptoms in-flight. Among other considerations, the increased incidence of infectious diseases in-flight requires additional resources to treat the crew and results in decreased crew performance. A HSP has been implemented since the Apollo 14 mission and has led to substantial mission success. The two biggest components of the HSP are pre-flight immunizations and quarantine. Through a combination of these two factors, in-flight infectious diseases (especially upper respiratory and enteric infections) can be mitigated. Current NASA/JSC protocol mandates the HSP begin 14 days prior to launch. If the crew will not be in space for a considerable amount of time (e.g., less than 1 day), an extensive HSP may not be as critical when compared to a longer-duration mission (e.g., Shuttle or ISS). However, physical contact between non-HSP and HSP crew must be considered. The HSP can only be successful if there is full participation by all in-flight physical contacts of the crew.



SpaceX Crew 1 during pre-flight quarantine



Shuttle program health promotion poster

Flight Crew Health Stabilization Program

Clinical Medicine

- Rapid Diagnosis
- Therapy

Immunology

- Serology
- Immunization

Exposure Prevention

- Fomites
- Consumables
- Contacts

Epidemiological Surveillance

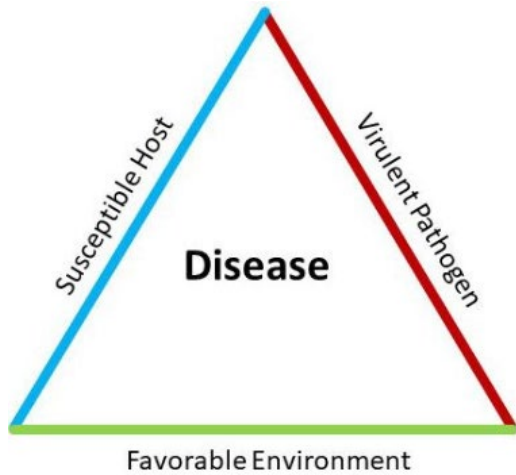
- Medical History
- Medical Surveillance



Background

The Physiology of Infectious Disease Transmission

An infection occurs when a virus or bacteria enters the body, multiplies, and causes a reaction (i.e., illness or disease). Epidemiologists utilize a three-part model for studying infectious disease and its spread, called The Epidemiologic Triad.



For a disease to spread, there must be:

1. A host that is susceptible to contracting the disease
2. A microbe/pathogen (either viral or bacterial)
3. An environment conducive to disease spread

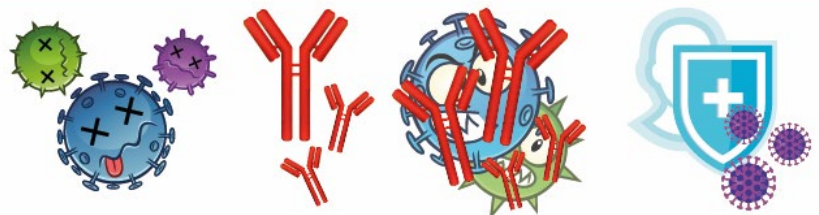
The 5 Stages of Infection

1. **Incubation** – The time from exposure to an infectious agent until the onset of symptoms. The incubation time varies depending on the disease type (see next page).
2. **Prodromal** – The time after incubation and before the symptoms of disease occur. During this stage, infected individuals are capable of transmitting disease to others.
3. **Illness** – The time at which an infected person presents clinical symptoms of a disease/infection.
4. **Decline** – The time at which the immune system creates a successful defense against the pathogen and the number of infectious particles decreases, with symptoms gradually improving. During this stage, a person is still capable of transmitting the pathogen to others.
5. **Convalescence** – The final stage of infection at which symptoms have resolved and individuals are no longer contagious and return to normal functioning.

The Health Stabilization Program seeks to protect crewmembers by:

- a) Quarantine procedures to prevent new exposure/infection by pathogens from potential carriers.
- b) Ensure if a crewmember has been exposed to a pathogen and may be in stages 1-3 of infection, to bring them back to convalescence prior to launch.
- c) Vaccinate crewmembers and close contacts to common diseases/illnesses to prevent infection if exposed.

HOW VACCINES WORK



A weak or dead form of the germ is introduced

This sparks your immune response to develop antibodies that remember the germ

The antibodies fight off the germ if it invades again



Background

Health Stabilization Program – Vaccination and Quarantine of Crew and Close Contacts

- Crewmembers and close contacts of crewmembers are required to receive vaccinations for diseases identified by medical support personnel to prevent the transmission and infection of illness.
- Crewmembers and close contacts also undergo a quarantine period prior to launch to prevent exposure to pathogens and ensure crewmembers are healthy prior to launch. Most illnesses that are not capable of being vaccinated against have less than 3 weeks incubation period (see table below).

[V1 3002] Pre-Mission Preventive Health Care Pre-mission preventive strategies shall be used to reduce in-mission and long-term health medical risks, including, but not limited to:

- h. Vaccinations (influenza, tetanus toxoid, varicella zoster vaccine, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), etc.
- k. Pre-mission Health Stabilization Program (HSP) to reduce the likelihood of contracting an infections disease before launch.

[V1 3012] Terrestrial Launch/Landing Medical Support All programs shall have medical capability at the site of terrestrial launch and landing to address nominal operations and launch/landing contingencies, including, but not limited to the following:

- a. HSP requirements for the crew, the crew’s family, and supporting personnel for purpose of disease prevention.

Example Incubation and Contagion Period of Common Diseases/Illnesses

Disease	Incubation Period	Contagious Period
Bronchiolitis	4-6 days	Onset of cough until 7 days
Colds	2-5 days	Onset of runny nose until fever gone
Coughs (viral)	2-5 days	Onset of cough until fever gone
Strep Throat	2-5 days	Onset of sore throat until at least 12 hours on antibiotics and fever gone
Shingles	14-16 days	Onset of rash until all sores have crusts
Fifth disease (Erythema infectiosum)	4-14 days	7 days before rash until rash begins
Diarrhea (bacterial)	1-5 days	Until stools are formed and fever gone
Diarrhea (viral)	1-3 days	Until stools are formed and fever gone
Vomiting (viral)	2-5 days	Until vomiting stops
Cold sores (herpes)	2-12 days	Until cold sores are dry (4-5 days)

Many respiratory infections may also be contagious 2 days prior to symptom onset and thus are difficult to control spread. Table based on information from Seattle Children’s Hospital <https://www.seattlechildrens.org/conditions/a-z/infection-exposure-questions/>



Background

Pre- and Post-Implementation of an HSP in Apollo Missions

Infectious diseases significantly impacted pre-flight and in-flight phases of Apollo missions 7 – 13. After the implementation of a flight crew HSP (FCHSP), a noticeable reduction in illness incidence occurred:

Mission	Illness	Number of Crewmembers Involved	Mission Phase
Before Implementation of FCHSP			
Apollo 7	Upper respiratory infection	3	Preflight, inflight
Apollo 8	Viral gastroenteritis	3	Preflight, inflight
Apollo 9	Upper respiratory infection	3	Preflight, inflight
Apollo 10	Upper respiratory infection	2	Preflight, inflight
Apollo 11	None	-	-
Apollo 12	Skin infection	2	Inflight
Apollo 13	Rubella	1	Preflight
After Implementation of FCHSP			
Apollo 14	-	-	-
Apollo 15	-	-	-
Apollo 16	-	-	-
Apollo 17	Skin infection	1	Preflight

- Prior to the HSP implementation, 57% of Apollo crewmembers experienced some level of infectious illness before flight
- Since Apollo 14, a HSP (featuring quarantines and immunizations) has been used before every flight to reduce infectious disease risk. While the risk cannot be completely eliminated, a comprehensive HSP presents a way to significantly reduce hazard

Reference Documents

- SP-368 Biomedical Results of Apollo, Section II: Crew Health and Inflight Monitoring
- Biomedical Results of Skylab, Chapter 7: Analysis of the Skylab Flight Crew Health Stabilization Plan
- SSP 50480-ANX1 Guidelines and Procedures for the Prevention of Infectious Disease Transmission to ISS Crewmembers
- JSC-22538 Flight Crew Health Stabilization Program, Rev. F



Reference Data

Past and Current HSPs

Apollo

- 21-day HSP for prime and backup crew
- Immunizations
 - Diphtheria, Pertussis, Tetanus, Typhoid, Influenza, Mumps, Poliomyelitis, Rubella, Rubeola, Smallpox, and Yellow Fever.
- Extensive disease exposure prevention via quarantine
 - Limited exposure to fomites, contaminated consumables, and interpersonal contacts
 - Crewmembers used different equipment
 - Closely controlled living environment – ultra-high efficiency bacterial filters, positive air pressure (outward flow of air only), and controlled food and water intake (including microbiological testing of samples)
 - No exposure to potential carriers (e.g., children, maintenance personnel); contacts restricted to medically approved individuals only (~100 people total)

Skylab

- 21-day pre-flight, 7-day post-flight HSP
- Immunizations similar to Apollo
- Quarantines to minimize crew exposure to infectious diseases; additional space for isolation of an ill crewmember
 - Similar to Apollo – positive air pressure
 - Primary contacts were inspected by a nurse before interaction with crew; interactions with non-primary contacts were performed via closed-circuit television (CCTV). Limitations set on number of primary contacts cited as the change that most significantly impacted incidence of disease.
 - Food was specially prepared for the crew

Space Shuttle Program

- 7-day pre-flight HSP
 - Quarantine facilities were made available 10 days pre-flight if needed for premature isolation
- Limited number of primary contacts, trained to avoid physical contact with crewmembers and heightened personal hygiene practices (e.g., hand washing); children <14 years of age restricted
- Pre-visit exams including temperature screening and vaccination requirements
- Maintenance of practices established during Apollo and Skylab, including vaccination and isolation space for crewmembers showing signs of illness while in quarantine
- The HSP was largely successful in preventing the occurrence of infectious disease that would affect launch; only one Space Shuttle flight was delayed because of infectious disease (respiratory) among the crew

ISS

- 14-day pre-flight HSP
- Countermeasures in place: crew and contact education; hand & respiratory hygiene; physical separation; personal protective equipment (PPE); immunizations (similar to Apollo); medical screening of contacts by medical personnel before crew interaction; and avoiding tasks with a high risk of infectious disease acquisition
- HSP participants are allowed to have close crew contact, but special guests and VIPs must stay >2 meters away and/or wear PPE. Participants are limited to 5 people or family members (with exceptions)
 - May be isolated prior to crew contact, depending on when they arrive at the site
- Additional considerations are in place for management of SARS-CoV-2 (COVID-19) risks



Application

Considerations when Implementing an HSP

- Back-up crewmembers, in addition to the prime crew, should be considered in the HSP in the event of crew swaps
- The incubation period for almost all non-immunization, preventable infectious diseases is ≤ 3 weeks
 - To ensure minimized risk, isolation/quarantine periods should include at least the 2 weeks prior to launch
 - Isolation/quarantine periods are reviewed and updated routinely based on evolving risks
- Access to quarantine facilities should only be for mission-required purposes
- Pertinent modes of transmission for infectious disease prevention include contact, droplet ($>5\mu\text{m}$), airborne ($\leq 5\mu\text{m}$), and blood-borne
- HSP Participants
 - Any individual who requires access to the quarantine facility for mission-related purposes – may or may not come into contact with the crew
 - Includes operational groups, crew family/personal contacts, special guests & VIPs, aircrew, and staff with access to the crew quarters/vehicle
 - All participants should be medically screened by physician or medical personnel via questionnaires and physical exams before contact with the crew

Current Immunizations Required for Crew and HSP Participants	
Measles	Poliomyelitis
Mumps	Varicella
Rubella	Hepatitis A & B
Diphtheria	Influenza
Pertussis	

Immunodeficiency of Deconditioned Crew

- Stress from spaceflight has shown subclinical research findings (findings that can be measured but do not require medical intervention) on immune system function.
- NASA continues to monitor immune system function but presently does not provide any additional post mission medical care related to the findings.
- NASA continues to ensure that crewmembers receive adequate nutrition, exercise, and behavioral health support to minimize the stress of spaceflight.
- Post-flight deconditioned crew care should consider each individual crew member’s personal health and relation to stress to determine if additional post mission quarantine measures are needed.

Studies have suggested that stress hormone levels are elevated post-flight and correlate with mission duration. T cell, natural killer cell, monocyte, and neutrophil function may diminish during and/or after spaceflight.

Source: Makedonas et al. (2020)



Back-Up



Major Changes Between Revisions

Rev B → Rev D

- Added background on disease transmission, vaccinations, and incubation periods
- Updated the relevant technical requirements

Rev B → Rev D

- Added information regarding immunodeficiency of deconditioned crew to slide 4

Rev A → Rev B

- Updated information to be consistent with NASA-STD-3001 Volume 1 Rev B and Volume 2 Rev D.

Original → Rev A

Slide 1:

- Reformatting of chart

Slide 2:

- Reformatting of chart

Slide 3:

- Medical screening of contacts by a physician → medical personnel
- Updated Personal Contacts (PCs) to HSP Participants
- Updated requirements for HSP participants (distance and number of participants allowed; use of PPE)
- Added statement for management of SARS-CoV-2 (COVID-19) risks
- Reformatting of chart

Slide 4:

- Added: isolation/quarantine period updates
- Updated Personal Contacts (PCs) to HSP Participants
- Added two immunizations to list [influenza, SARS-CoV-2 (COVID-19)]
- Removed the following statement: "Influenza vaccination is not a requirement; if the PC has not received, then they must wear PPE"



Referenced Technical Requirements

NASA-STD-3001 Volume 1 Revision B

[V1 3002] Pre-Mission Preventive Health Care Pre-mission preventive strategies shall be used to reduce in-mission and long-term health medical risks, including, but not limited to:

Flight surgeon monitoring of crewmembers during hazardous training and pre-flight science testing.

- a. Optimization of nutrition.
- b. Vitamin D supplementation.
- c. Triennial imaging of bone mineral density.
- d. Maintenance of optimal aerobic and strength physical fitness.
- e. Maintenance of flexibility, agility, and balance.
- f. Annual physicals.
- g. Preventive dental care.
- h. Vaccinations (influenza, tetanus toxoid, varicella zoster vaccine, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), etc).
- i. Behavioral health resiliency training.
- j. Total radiation dose control/monitoring.
- k. Pre-mission Health-Stabilization Program (HSP) to reduce the likelihood of contracting an infectious disease before launch.
- l. Assisted Reproductive Technology (ART) if desired by the crewmember to preserve gametocytes prior to missions with exposure to radiation.

[V1 3012] Terrestrial Launch/Landing Medical Support All programs shall have medical capability at the site of terrestrial launch and landing to address nominal operations and launch/landing contingencies, including, but not limited to the following:

- a. HSP requirements for the crew, the crew's family, and supporting personnel for purpose of disease prevention.
- b. Access to the full spectrum of medical capabilities, from routine medical and mental health care to advanced trauma life support (ATLS) capabilities, or equivalent.
- c. Incorporation of civilian and/or Department of Defense (DOD) facilities and Emergency Medical Services (EMS).



Reference List

1. NASA-STD-3001 Volume 1, Revision A with Change 1. (2015).
<https://www.nasa.gov/sites/default/files/atoms/files/nasa-std-3001-vol-1a-chg1.pdf>
2. SP-368 Biomedical Results of Apollo, Section II: Crew Health and Inflight Monitoring.
<https://history.nasa.gov/SP-368/contents.htm>
3. Biomedical Results of Skylab, Chapter 7: Analysis of the Skylab Flight Crew Health Stabilization Plan. https://lsda.jsc.nasa.gov/books/skylab/biomedical_result_of_skylab.pdf
4. SSP 50480-ANX1 Guidelines and Procedures for the Prevention of Infectious Disease Transmission to ISS Crewmembers
5. JSC-22538 Flight Crew Health Stabilization Program, Rev. F
6. Makedonas, G., Mehta, S.K., Scheuring, R.A., Haddon, R., and Crucian, B.E. (2020). SARS-CoV-2 Pandemic Impacts on NASA Ground Operations to Protect ISS Astronauts. *The Journal of Allergy and Clinical Immunology: In Practice*, 8(10): 3247-3250.
<https://doi.org/10.1016/j.jaip.2020.08.064>