A Brief History of NASA's Contributions to Telemedicine
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Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC)'s Mobile Health Unit (MHU)
Image Credit: NASA

A highly infectious disease, caused by the COVID-19 virus, has taxed societies and health care systems across the world. Insufficient numbers of physicians and hospital beds to diagnose and treat the tremendous surge of those who have fallen seriously ill with the coronavirus, let alone all those patients who need other medical care, has raised important questions about the capacity and capability of current health care systems to address pandemic events. One solution to potential overcrowding and resource scarcity is the integration of telemedicine more fully into current clinical practice.

For more than 60 years, NASA has played a very significant role in helping develop and promote a variety of remote medical monitoring and treatment solutions both for astronauts and for the general population. Today, NASA is once again poised for a leadership role to help health care providers and patients navigate the challenges of the current moment.

On Earth and in the Heavens

The roots of telemedicine at NASA are entwined with the Agency's earliest days and the modern history of human spaceflight. The dominant medical question prior to Yuri Gagarin's successful spaceflight in April 1961 was whether the human body could function in space. In particular, physicians were concerned that the absence of gravity could impede circulation, respiration, and digestion.[1] To determine if this would indeed be a problem, both the U.S. and the Soviet space agencies performed a number of test flights using animals attached to medical monitoring systems, which sent the animal's biometric data to scientists on Earth via a telemetric link. Even after it was determined that spaceflight posed little risk to circulatory and respiratory health, NASA still sought to understand if spaceflight would have any other physiological or psychological effects on the human body.[2] The focus on possible limitations of the human body forced the agency to take a technologically-focused approach to telemedicine. As Dr. Sherman Vinograd, then Chief of Medical Research in the Directorate of Space Medicine, noted "the concern of the medical scientists centered mostly on assuring man's support in space and his safe return to Earth—while predetermined engineering goals were achieved." This, continued Vinograd, meant that medical research outside of monitoring was "secondary to the engineering objectives of the mission."[3]

The culmination of this engineering-focused approach came with the introduction of the Integrated Medical and Behavioral Laboratories and Measurement Systems (IMBLMS) program in 1964.[4] IMBLMS was an expansion of the measurement systems debuted on the Mercury and Gemini flights. IMBLMS, however, was designed from the outset to do more than simply revamp existing technology from ongoing human spaceflight programs—rather NASA viewed the program, and the new and upgraded technology created as part of it, as critical for supporting its post-Apollo goal of conducting longer duration human spaceflights, especially supporting the eventual construction and occupation of an orbiting space station. In situations where a quick return to Earth was not possible, the ability not only to monitor biometric data, but also to engage at least rudimentary-guided medical treatment by non-physicians was critical: if a medical emergency arose, astronauts would have only their crewmates to accurately diagnose them. But rising inflation and the subsequent funding cuts for human spaceflight programs as the Apollo program wound down, pushed NASA's ambitious plans for the IMBLMS program to margins of the Agency's funding priorities during the late 1960's and early 1970's.

The New Telemedicine at NASA: STARPAHC and Beyond

IMBLMS might have stayed a partially realized dream if not for a letter from the White House Domestic Council in July 1971. This new initiative explored ways to inexpensively stimulate a flagging economy by using government programs already in development. Administrators at NASA saw the Domestic Council's request as an opportunity—if NASA couldn't test IMBLMS in space why not build a terrestrial analog? The result was a new program, Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC).

While building terrestrial analogues was a fairly common practice at NASA, STARPAHC represented an important new direction for the agency, largely because the technology generated was designed from the outset to serve a broader group than just astronauts. The search for this expanded clientele was driven both by political considerations from the White House, and the need to spread the development costs across multiple parties—this forced NASA to seek a diverse range of partners including new groups like the Indian Health Service and the Papago (now Tohono O'odham) people of Southern Arizona.[5] NASA also sought to engage long-time collaborators like the Lockheed Missiles and Space Company, which was the primary contractor for IMBLMS, as a way to ensure that existing technical knowledge involving microwave relays and other communications technologies could quickly be leveraged.[6]

The remote location of the Tohono O'odham reservation, and the fact that the State of Arizona was one of only a handful to allow the delivery of care by paraprofessionals such as physician's assistants, ensured that the terrestrial analogue would more closely resemble the situation aloft.[7] NASA was involved in STARPAHC from 1973 until 1977, with NASA taking an active early role in the program to design and the test the technology that linked rural patients in mobile support units with physicians in Indian Health Service hospitals in Sells and Phoenix, Arizona. The project continued, without NASA, into the 1980s. The focus on interagency and interpersonal cooperation that underpinned STARPAHC imploded the technocratic focus of prior NASA telemedicine efforts. As a 1974 NASA report noted, "this approach [cooperative telemedicine] has 'spin-off' potential, in that space technology employed in the basic design of a flight system may be extremely beneficial to improving the quality of health care delivery here on [E]arth." Moreover, the report continued STARPAHC was "a necessary step" for improving health care delivery for both astronauts and ordinary Americans.[8]

IMBLMS and STARPAHC set the stage for NASA's national and international role in telemedicine during the 1980s and 1990s. In doing so, it provided an excellent opportunity to transfer space technology to the betterment of humankind. Disasters, including earthquakes in Mexico City (1985), and Soviet Armenia (1988) served as opportunities to apply NASA-derived technology in health emergencies on Earth.[9]

NASA's efforts in Armenia were particularly important because they began a period in the Agency's history where telemedicine served as a way to expand international cooperation. Earlier, the U.S./U.S.S.R. Joint Working Group (JWG) on Space Biology and Medicine set the stage during the Apollo-Soyuz Test Project (ASTP) of 1975.[10] The cautious dialogue on space health and medicine during the early 1970s evolved into more institutionalized biomedical communication through the JWG. By the time of the devastating Armenian earthquake in 1988, there was an established track record of international medical cooperation and a basic understanding of each side's telemedical capabilities. The Armenian program, which operated between May and July of 1989 and became known as the "Spacebridge to Armenia," provided much needed medical communications and virtual medical support for the communities in Armenia affected by the earthquake and is perhaps the most cited example of how shifting social and technical goals altered the Agency's telemedicine program by the 1980's.[11]

In addition to its social and diplomatic aims, the Spacebridge to Armenia was, like STARPAHC before it, an important way to test technological innovations in anticipation of the construction of a new space station. Consequently, the program generated important lessons that NASA would apply to later telemedicine efforts, including meeting technical challenges like establishing a multi-site video connection across multiple time zones; identifying personnel in both countries with appropriate technical skills; and finding the best forms of media to securely transmit complex patient information.[12] The Spacebridge to Armenia also addressed such concerns as understanding the effect of trauma on individual health, and engaging in a frank discussion of medical ethics and informed consent across different medical traditions.[13] Subsequent efforts were made to establish a “Spacebridge to Moscow” during the early 1990’s and a “Spacebridge to Russia” in 1994 that further refined the technology used to transmit and analyze medical information and strengthened interpersonal relationships between physicians and medical technologists in both countries.[14] This project was at the forefront in the integration of medicine with the Internet and the World Wide Web.

Dr. Arnauld Nicogossian, former Associate Administrator for Life Sciences and Microgravity Sciences, and others at NASA, including Charles Doarn, former Program Executive for Aerospace Medicine and Telemedicine, saw the value of commercializing telemedicine technology as a way to encourage more rapid technical development, to promote a wider diffusion of the technology to a non-governmental audience, and finally to defray development costs for NASA. Nicogossian and Doarn’s push for the commercialization of telemedical technology was in line with an agency-wide mandate to spin off the benefits of human spaceflight and other scientific and technical endeavors—a mandate that has guided NASA since the early 1960’s.[15] In order to better facilitate this, in 1997, the agency sponsored the creation of a Commercial Space Center named Medical Informatics and Technology Applications Consortium (MITAC) at Yale University (it later moved to Virginia Commonwealth University). Until its closure in 2007, MITAC not only pursued a range of telemedical projects and but most importantly created a variety of different terrestrial test beds for new technology in remote locations in Ecuador, Russia, and the Arctic.

Telemedicine at NASA Today

NASA has integrated telemedicine into every human spaceflight program, including the International Space Station and Artemis. Telemedicine remains an important priority for NASA and an integral part of medical operations. The focus of current Agency efforts has expanded beyond the original mandate of telemetry and remote communication to encompass new “smart medical systems” that are designed not simply to communicate and diagnose ill astronauts—but also to provide physicians on the ground with the ability to remotely provide limited treatment options. The integration of treatment and communication capabilities represents an important direction for the future of human space flight and emergency care for remote patients on Earth.

For this next phase of efforts to improve space medicine, NASA has built strong relationships with its partners in the academic and private sectors. Partnerships with academic institutions help to ensure that NASA can draw from a deep pool of talent, regardless of proximity to existing NASA field centers, to support the biomedical research efforts and through Health and Medical Technical Authority, assure that human systems integration and human factors are key elements of crew health and safety. Telemedicine will continue to be a cornerstone of healthcare in support of human spaceflight.

NASA integrates and utilizes telemedicine as a tool to support human spaceflight. Over the last 20 years or so, global digital telecommunications and the Internet have rapidly expanded such that it is now possible for medical practitioners to provide expert diagnoses and care remotely. While few laypeople could have foreseen telemedicine’s value during a global pandemic, it is fortuitous that the medical care and public health systems have such tools available to help them help patients in a time of great need. Thus, in a small way, as the STARPAHC and the

Spacebridge projects have shown, the benefits of NASA's telemedical efforts go beyond the technical and also have important social and humanitarian benefits.

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[1] For more on space medicine during the Mercury, Gemini and Apollo programs see Mae Mills Link, *Space Medicine in Project Mercury* (Washington, DC: NASA SP-4003, 1965) and John Pitts, *The Human Factor: Biomedicine in the Manned Space Program to 1980* (Washington, DC: NASA SP-4213, 1985).

[2] To learn more about the psychology of human space flight see Douglas A. Vakoch, ed. *Psychology of Space Exploration* (Washington, DC: NASA SP-2011-4411, 2011).

[3] "Aim of Medical Experiments Program: To Better Know Earth-Man in Space" *Aerospace Management* 1970. 5(1):63-71. Quotation on 63.

[4] Lockheed Missiles and Space Company, "STARPAHC Systems Report vol. 1" 30 October 1977, copy in "Telemedicine STARPAHC" file, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC. 2-1.

[5] Rashid Bashshur, "Technology Serves the People" Report prepared for STARPAHC Office of Research and Development 1979 "Telemedicine STARPAHC" file, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC. For more on the STARPAHC project, see Andrew T. Simpson, Charles R. Doarn, and Stephen J. Garber, "Interagency Cooperation in the Twilight of the Great Society: Telemedicine, NASA, and the Papago Nation," *Journal of Policy History*. 2020; 32(1):25-51.

[6] Bashshur. 24.

[7] "Space Technology in Rural Health Care" August 1974 "Telemedicine STARPAHC" file, NASA Historical Reference Collection, History Division, NASA Headquarters, Washington, DC. 2.

[8] "Space Technology in Rural Health Care" 2. See also Gary Freiburger, Mary Holcomb, and David Piper, "The STARPAHC collection: part of an archive of the history of telemedicine" *J Telemedicine and Telecare,* 2007; 13:221-223.

[9] There was also, especially in the case of the Armenian earthquake, the sheer scale of the disaster—estimated causalities were over 50,000 people and an additional 500,000 people were left homeless. See Arnauld E. Nicogossian and Charles R. Doarn, "Armenia 1988 Earthquake and Telemedicine: Lessons Learned and Forgotten" *Telemedicine and e-Health Journal.* 2011; 17(9):741-745.

[10] Charles R. Doarn, Arnauld E. Nicogossian, Anatoly I. Grigoriev, Galina Tverskaya, Oleg I. Orlov, Eugene A. Ilyin, and Kenneth A. Souza, "A summary of activities of the US/Soviet-Russian joint working group on space biology and medicine" *Acta Astronautica* 2010; 67(7-8):649-658.

[11] Nicogossian and Doarn, "Armenia 1988 Earthquake" and Charles R. Doarn and Ronald C. Merrell, "Spacebridge to Armenia: A Look Back at Its Impact on Disaster Response" *Telemedicine and e-Health Journal* 2011; 17(7):546-552.

[12] To learn more including about the development of the Telemedicine Instrumentation Pack (TIP) see Arnauld E. Nicogossian, Debra F. Pober, and Stephanie A. Roy, "Evolution of Telemedicine in the Space Program and Earth Applications" *Telemedicine and e-Health Journal* 2001; 7(1):1-15

[13] Ibid and Nicogossian and Doarn.

[14] See Nicogossian et al. to learn more about other international telemedicine projects conducted during the 1990's. In an interview conducted with the author in June 2013 at NASA headquarters, Charles Doarn also noted the involvement of prominent Houston surgeon Michael E. DeBakey as a leader in helping to build durable interpersonal relations through telemedicine between the United States and Russia. Also, Doarn CR, Nicogossian AE, Merrell RC. Application of Telemedicine in the United States Space Program. *Telemedicine Journal* 1998; 4(1):19-30.

[15] See http://spinoff.nasa.gov/spinhist.html for more about NASA's spin-off program.