

COMMENTARY ARTICLE

CONTRIBUTIONS OF SPACE TECHNOLOGY TO GLOBAL HEALTH IN THE CONTEXT OF COVID-19

Kontribusi Teknologi Antariksa untuk Kesehatan Global pada Konteks COVID-19

*Shannon Suryaatmadja¹, Nova Maulani²

¹Faculty of Law, UNIKA Atma Jaya, Indonesia

²Directorate General of Legal Affairs and International Treaties, Ministry of Foreign Affairs of the Republic of Indonesia

*Correspondence: shannon.me@outlook.com

ABSTRACT

Background: Space technologies have been used in each aspect of mankind's life, including health. The United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) has instigated several programs to address how space technologies can contribute to global health.

Aims: This article deepened the understanding of how space technology contributes to global health and identified how it may be used in the context of COVID-19.

Results: This research identified four different domains of space technology that can or may contribute to global health, which are remote sensing, global navigation satellite system, satellite communication, and human space flight. Generally, these four domains can track disease outbreaks and help mitigate its spread such as by minimizing patient contact with medical personnel. They also keep daily activities such as communication and work afloat. Future developments in space technologies may prove to have an even bigger role to minimize spread.

Conclusion: Space technologies are invaluable in helping healthcare personnel and governments track the disease's sources and spread. Also, they can identify locations with the most damage, and thus immediate actions can be taken.

Keywords: geographic information system, infectious disease, outbreak, remote sensing, space technology.

ABSTRAK

Latar Belakang: Teknologi antariksa telah digunakan dalam tiap aspek kehidupan manusia, termasuk kesehatan. United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) telah mencetuskan beberapa program untuk menyikapi bagaimana teknologi antariksa dapat berkontribusi bagi kesehatan global.

Tujuan: Artikel ini memperdalam ilmu mengenai bagaimana teknologi antariksa berkontribusi untuk kesehatan di dunia dan mengidentifikasi bagaimana teknologi antariksa dapat digunakan dalam konteks COVID-19.

Hasil: Penelitian ini mengidentifikasi empat bidang teknologi antariksa yang dapat atau mungkin dapat berkontribusi bagi kesehatan global, yakni penginderaan jauh, sistem navigasi satelit global, komunikasi satelit, dan penerbangan antariksa berawak. Secara umum, keempat bidang ini mampu melacak wabah dan membantu memitigasi penyebarannya seperti melalui meminimalkan kontak pasien dengan tenaga kerja medis. Teknologi antariksa juga membantu kegiatan sehari-hari seperti komunikasi dan pekerjaan tetap berjalan. Perkembangan teknologi antariksa di masa depan dapat memiliki peran lebih besar untuk meminimalkan penyebaran.

Kesimpulan: Teknologi antariksa berperan penting dengan membantu tenaga kerja medis dan pemerintah melacak sumber dan penyebaran penyakit. Teknologi antariksa juga mengidentifikasi lokasi yang terkena dampak terparah, sehingga tindakan dapat segera dilakukan.

Kata kunci: sistem informasi geografis, penyakit menular, wabah, penginderaan jauh, teknologi antariksa.

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INTRODUCTION

The COVID-19 pandemic has forced billions of people to stay at home or be quarantined in a health facility (Langton, 2020). It has changed the way modern society lives, works, and connects to others

(Singh, 2020). Compared to past pandemics such as the Spanish flu pandemic in 1918, society has the technology to stay in touch with family members and coworkers residing in different homes. During the 2020 COVID-19 pandemic, health facilities, logistics,

transportation, education, and other vital businesses must continue operating, and governments have to work together to make sure the society's needs have been met. Also, they have to ensure the COVID-19 spread could be minimized.

Space technology itself is an overarching term defined as technology related to the exploration of and activity in space, referring to satellites infrastructure and aerospace industry (Lexico, 2020). It is a once-foreign concept that has gradually integrated itself into mankind's daily life. The existence of space technology allows effective communication, navigation, and much more. However, current and potential contributions of space technology to better healthcare are still often overlooked.

In the past, space technology helped to track cholera in Bangladesh. In hindsight, space technology may have predicted the occurrence of cholera in South America in 1991. It also tracked and predicted malaria outbreaks in the sub-region of Saharan Africa (Ford *et al.*, 2009).

This study aims to deepen the understanding of how space technology contributes to global health, specifically in combating infectious diseases. It also identifies how space technology has or may be used in the context of COVID-19 mitigation.

An overview is given at the beginning to give some context and familiarize the readers with ongoing space and global health programs conducted or planned under the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). It then identifies the utilization of space technologies for the betterment of healthcare with possible uses which may help to fight against COVID-19. Lastly, it specifically discusses how Indonesia up to April 2020 has utilized space technology for mitigating COVID-19 before reaching to conclusions.

This study is expected to contribute to a greater understanding of how space

technology has affected global healthcare. This study also hopes to spark similar interests of further studies in this topic.

DISCUSSION

This commentary article is supported with references from articles, space law books, UN Resolutions, and other multilateral meeting documents that discuss the use of space technology for global health, particularly in the COVID-19 context. The selection of articles or references may be prone to bias since the topic of space and global health has only recently been put into focus.

Overview of Space and Health Programs

UNCOPUOS is the United Nation's focal point for issues pertaining to international outer space. It has two permanent subcommittees; the Legal Subcommittee (LSC) and the Scientific and Technical Subcommittee (STSC). Each subcommittee holds annual meetings known as sessions and gives reports of these sessions during the annual UNCOPUOS main session (also referred to as the "parent"). Then, UNCOPUOS will report the results to the United Nations General Assembly (UNGA).

In 2015, the United Nations through Resolution A/RES/70/1 developed an action plan for the people, planet and prosperity, known as the 2030 Agenda for Sustainable Development (2030 SDGs) which contains 17 challenges. From a short glance, the use of space technology plays an important role to fulfill the SDGs' ambitions.

The journey to this ambition was captured by the "Space2030" agenda, which UN Member States negotiated over the next two years following the resolution through the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS). The Space2030 agenda promises a change on how space is considered in the UN system

(United Nations Office for Outer Space Affairs, 2015), in which Member States laid out a vision to enhance the use of space science and technology for the attainment of the 2030 Sustainable Development Agenda (United Nations Office for Outer Space Affairs, 2018).

The UNCOPUOS also has working groups dedicated to certain issues, including the Space 2030 formed with the purpose to implement the Space 2030 agenda. These working groups collaborate on the basis of a strategically comprehensive, inclusive, and oriented visions for strengthening international cooperation in the exploration and peaceful uses of outer space (United Nations General Assembly, 2020). This agenda was mentioned in the United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE+50) to reflect on more than 50 years of space exploration achievement to strengthen global cooperation in outer space and its use for sustainable development.

The UNCOPUOS Meeting in 2018 also agreed with the role of Expert Group on Space and Global Health. This Expert Group identified four different domains of space technology that are or may be applied to contribute to global health, such as (A) remote sensing, (B) global navigation satellite system (GNSS), (C) satellite communication, and (D) human space flight (Dietrich *et al.*, 2018).

It is important to note that although the four domains manifest into different technologies, there are intersections between them. These domains are created based on the functions of space technology. Noticeably, a single satellite may be equipped with several kinds of satellite technologies, and thus it can serve more than one function. An apparent example is space technologies in the remote sensing and GNSS domains, which use satellite to record information on the

Earth's surface by producing images. GNSS, therefore, can fulfil the function of a space object to conduct remote sensing.

There are several differences between the two (Dietrich *et al.*, 2018). GNSS must consist of multiple satellites to maintain constant signal broadcast, while it is common to use a single satellite in remote sensing. While a GNSS is able to track moving objects, remote sensing focuses on collecting data to reproduce what is happening on a certain location at a specific time.

The following parts of this study discuss each key domain in space activities that have directly been used in health sectors. It looks at the definition of each domain with familiar examples for readers and how space technologies in that particular domain function. It also put descriptive case studies on how the space technology in question has been conducted and applied during the COVID-19 outbreak.

Domain A: Remote Sensing

Space technology is used to mitigate COVID-19 spread is through remote sensing. Remote sensing is defined as gathering information from a distance without making contact with the object observed, similar to how human eyes or camera lens work (Dietrich *et al.*, 2018). Space technologies used for remote sensing are equipped with sensors which can be used by scientists to observe the properties of electromagnetic waves emitted, reflected, or diffracted by the sensed objects. These waves are then studied further to identify and/or classify the aforementioned objects (Dunk and Tronchetti, 2015).

Having an eagle's eye of the Earth's surface has always been beneficial for healthcare. Before the mass use of space technology, the visualization of the relation between location and health was done through cartography. In fact, a 2014 study of the health GIS literature found that

infectious disease mapping became the focus of 248 out of 865 (28.7%) papers reviewed (Lyseen *et al.*, 2014).

The earliest recorded map visualization was in 1694 on plague containment in Italy. Within the next 225 years, the value of maps as a communication tool blossomed in the service of understanding and tracking infectious diseases. Several diseases such as yellow fever, cholera, and the 1918 influenza pandemic were tracked, and to some extent their spread was also predicted (Boulos and Geraghty, 2020).

Since the 1960s, when computerized geographic information systems were born, analyzing, visualizing, and detecting disease patterns dramatically had increased. Space technology in the form of remote sensing will only serve to exponentially increase mapping capabilities for healthcare.

Essentially, satellites which perform remote sensing can create high quality maps (depending on how advanced the technology is) of a designated area. Having a satellite that can periodically or continuously take images allows to track the sensed object or area.

Pertaining to healthcare, remote sensing is commonly utilized to monitor environmental changes, which could be proven useful in predicting diseases. Bangladesh used remote sensing to address a cholera break. By collecting information from the sea temperature, surface height, and chlorophyll A levels, scientists were able to predict the actual cholera incidence rate in Bangladesh by constructing an environmental model (Christaki, 2015).

Identifying the time frame in which an outbreak is likely to occur can inform public health workers to take action. Simple steps can be taken to stress the importance of basic hygiene and sanitation and implementing simple mitigation efforts. In Bangladesh, simple steps such as filtration

of water with sari cloth was credited in several areas by reducing deaths due to cholera by over fifty percent (Ford *et al.*, 2009; Christaki, 2015).

Another case is how satellite imagery can monitor the spread of vector-borne diseases. It has been used to track malaria in sub-Saharan Africa by predicting the distribution of five of the six *Anopheles gambiae* complex species for a large amount of malaria transmissions throughout the African regions (Ford *et al.*, 2009).

The result accuracy was dependent on the amount of data available for disease modeling (Christaki, 2015). The constant improvement in disease modelling and the increase of satellite data accuracy through real-time collection of information on location help to ensure that satellite imaging will be capable of providing tremendous prediction powers for infectious diseases.

In the present context of COVID-19, satellite imagery has been used to analyze the way humans interact with other humans and animals. Satellite imagery can monitor boundaries where humans live near wildlife, which is important because animals can be the source of disease outbreaks. Satellite images also can be used to study anomalies in the environment such as differences in weather, temperature, and other factors that may affect animal migrations which could bring and spread diseases (Rodríguez, Quarantelli and Dynes, 2007).

Since the imagery can be monitored for long periods of time, remote sensing is also used to indicate successful lockdown or quarantine procedures enacted in many areas across the globe such as in China, Europe, and the United States. Satellite images can also predict the spreading virus' centrum based on human behavior (such as crowded beaches or religious gatherings) or the behaviors and movements of wild animals if necessary.

Public places are monitored to ensure no activities operate, thereby helping to contain further spreading (Planet.com, 2020).

Space technology, including remote sensing, is often combined with other technologies such as Bluetooth or Artificial Intelligence to garner best results. To denote this potential, the Indonesian Ministry of Communication and Information Technology has recently launched an application called *PeduliLindungi* as a measure to contain the COVID-19 outbreak (Public Relations Bureau of the Ministry of Communication and Information Technology, 2020). This application uses Bluetooth technology to track COVID-19 spread and alerts its users if they are entering an area with a high number of people infected by COVID-19. It also has a QR (Quick Response) Code scanner for providing rapid tests to patients and people who still need to travel during the pandemic (PeduliLindungi, 2020). *PeduliLindungi* is equipped with telehealth as well, which is a form of space technology that will be further explained in the satellite communication domain.

Remote sensing can help to map the distribution of health institutions or testing facilities according to the movement of people (Rodríguez, Quarantelli and Dynes, 2007). When planes and unmanned aerial vehicles are too difficult to use in the period of COVID-19, space assets can fill this role. This means society can be directed to the nearest health facility that still holds capacity to treat more patients.

A related and complementary voluntary system was implemented in Guangzhou Underground, China's underground train system in Guangdong Province. Since 17 February 2020, each of the train's carriages has been equipped with a unique QR code that can be scanned by passengers once they board that particular carriage. The passengers then fill their personal data such as identification

number (optional), gender, and their route by selecting their starting station and destination station (Boulos and Geraghty, 2020). If passengers wish to move to another carriage, they must scan the new QR code and repeat the same process. If an individual is unfortunately diagnosed with COVID-19, their transport routines will be easily tracked. The government can notify passengers who boarded the same metro carriages at the relevant time.

Satellite images also can be used to track and analyze the possibility of the lack of food supply by monitoring the agriculture area. They also can be used to study and analyze the impact of the pandemic to certain businesses, such as tourism, retail shops, and public transportation.

Domain B: Global Navigation Satellite System (GNSS)

The Global Navigation Satellite System (GNSS) is a space-based system designed to transmit signals. It has three key functions, i.e. Position, Navigation, and Timing (PNT). The GNSS consists of the space segment, the ground segment, and the user segment (Jakhu and Dempsey, 2017). The space segment comprises of a group of satellites, referred to as a constellation. The GNSS is also commonly known under another name, Geospatial Information System (GIS). In the most basic sense, this technology allows geographic data (including hazard-related data) to be mapped and then transformed into interactive visual information. The user can manipulate the data to control the desired interaction.

Each GNSS or satellite constellation has autonomous geo-spatial positioning capabilities. These constellations detect and locate an object with an accuracy from several meters to centimeters, depending on how advanced the system is. Because of its constellation form, the GNSS is constant and thus able to send a continuous signal to its recipient on Earth.

The recipient has access to receive signal broadcasts from at least four satellites simultaneously. Broadcasts are then calculated to determine location, altitude speed, and direction by calculating the time the signal spends to travel from the satellites to the recipient (Jakhu and Dempsey, 2017).

This means the GNSS is the perfect system to conduct tracking and surveillance. It enables an increased use of spatial analysis to identify the ecological, environmental, and various other factors which contribute to the spread of vector-borne diseases and disease pattern monitoring. Thus, users can define areas that require disease-control planning.

The past decade has seen a tremendous growth for several countries to create and operate their own satellite constellations. Some of these are the Global Positioning System (GPS) owned by the United States of America (US), Global Navigation Satellite System (GLONASS) owned by the Russian Federation, and Galileo owned by the European Union (EU). Executing this system means the operating country—and any other parties that are given access—will be able to have a bird's eye view of Earth at a certain level similar or more advanced to that of Google Maps.

As previously mentioned, the GNSS technology is fundamentally used to explore spatial relationships. For example, a disaster manager could figure out which public facilities such as roads or hospitals that may be affected by earthquakes or floods (Rodríguez, Quarantelli and Dynes, 2007). A single advanced GNSS also can show live and continuous feed of satellite images akin to remote sensing. This means the operators can get data on which health facilities are affected by quarantine measures and identify areas that need fast medical supply rerouting.

In the US and China, during the COVID-19 pandemic, governments used

geospatial information to feed fresh data to the artificial intelligence system built to solve logistic problems. This includes the distribution of healthcare items and food. The US-based Atlanta Community Food Bank (ACFB) launched its COVID-19 Help Map for families in need. It has helped weekly deliveries of over 100 tons of food to 21 locations for those affected by school and business closures (Thomas, 2020).

Fresh data is crucial to make sure patients and the local resident receive facilities and basic necessities that they need without traveling. This technology allows several data to be combined, including manual data input by the residents, patients, workers, and the acquired geospatial data.

Due to social distancing, lockdowns, quarantines, and other measures taken across the globe, online shopping is the only viable option for many people to get their daily necessities. GNSS technology can track facilities such as food banks, open restaurants, or even grocery shops that have online delivery. It maps the data and enables supply chains to adapt to the ever-changing conditions during the pandemic. As a result, people can manage to survive or at least feel more normal by getting goods and services needed with the help of this technology.

An initiative stemming from the US is HealthMap, a healthcare application. HealthMap was found back in 2006 by a team of epidemiologists, researchers, and software developers at Boston Children's Hospital. It performs by utilizing online informal sources to search for data which can be used to monitor disease outbreaks and perform surveillance to identify emerging threats to public health in real time (Boulos and Geraghty, 2020). It collects outbreak data from a range of sources including but not limited to news networks, social media, validated official alerts such as the World Health

Organization (WHO), and experts' curated accounts.

In the context of COVID-19, HealthMap managed to curate an interactive map which shows geolocation updates from the aforementioned sources, and thus users can grasp a better understanding of how the pandemic spread. It has an "outbreaks near me" feature which informs users of nearby disease transmission risks based on their current location, obtained from the user's device (Boulos and Geraghty, 2020).

Similar to HealthMap, Canada has BlueDot, a firm specializing in automated infectious disease surveillance. The firm uses natural language processing techniques and machine learning to filter news reports, forums, blog posts, disease networks, and various data in 65 languages. The data is periodically sifted to find indications of possible disease outbreaks through any unusual events. Trained epidemiologists employed by BlueDot further analyze the automated data for any outbreak prior to releasing them to clients (Boulos and Geraghty, 2020). As a result, the firm was considered as the earliest platform to give news of the COVID-19 outbreak which firstly began in China.

Like remote sensing, the GNSS technology also can be used to analyze the impact of COVID-19 on various business industries, including but not limited to air travel, tourism, and trading (European Global Navigation Satellite Systems Agency, 2020). The data in flight radars showed that the number of flights has plummeted, and the movement of tourism ships that has still operated also follows this trend (Scatteia and Ravichandran, 2020).

Domain C: Satellite Communication

When discussing satellite communication, it must be distinguished from communication methods which only make use of radio signals for sending and

receiving a message. Rather, it must use specifically designed satellites as part of an infrastructure to transmit messages {Formatting Citation}.

Satellite communication's main contribution to global healthcare is through telemedicine technology. Telemedicine is the delivery of healthcare and its exchange across distances in instances where medical expertise or resources are not readily available on site for various reasons. Usage of telemedicine may be incurred by geographical distance, the existence of physical barriers such as mountainous or extreme terrains, and insufficient resources when transferring a patient.

Patients under the treatment by a health care provider in rural areas can be connected with specialists in urban areas. For instance, Thailand's telemedicine network is connected through THAIOM, the country's first satellite dedicated for communication launched in 1993. Under the Ministry of Public of Health, all hospitals within the telemedicine network have access to a direct communication link with the government base (Dietrich *et al.*, 2018). This communication link means guaranteed access to experts' opinions among general practitioners, nurses, paramedics, or specialists, often accompanied by images from radiography or dermatoscopy. The images used were predominantly 2D and non-animated images until recent advancements that enabled the transfer of 3D images and live ultrasound feed.

The use of telemedicine surprisingly is effective for a nation's defense system (Dietrich *et al.*, 2018). Each of Germany's defense units is equipped with medical officer personnel on board with access to telemedicine workstations. Each of these stations may have devices such as X-ray film digitizers, dermatoscopes, otoscopes, ultrasounds, and video cameras. Another example comes from the US Navy. Over

300 US Navy ships are equipped with telemedicine features, and there have been estimations that 17% of medical evacuations can be avoided. This finding potentially saved the US as much as \$4400 per medical evacuation (Dietrich *et al.*, 2018).

The Project Emergency Telehealth and Navigation (ETHAN), initiated by the Houston Fire Department in 2014, is another program which combines telehealth, social services, and alternative transportation to navigate primary care-related patients. The project aimed to make the emergency care system more efficient (Langabeer *et al.*, 2016). Since emergency medical service agencies dominantly mobilize patients with non-emergent and low acuity conditions to Houston's local emergency departments, ETHAN may improve the emergency system's capacity.

During the first year, 5,570 patients participated in ETHAN. The participant group was compared with a control group of the same size. Results of this study found a 56% absolute reduction of the time ambulance trips to and from emergency departments. The median time for the productivity of emergency medical services was also reduced by a 44-minute average, dropping from 83 minutes to only 39 minutes (Langabeer *et al.*, 2016). The productivity time is the median time measured from the time the emergency medical services receive a notification to when the ambulance returns to the hospital.

For patients with more severe illnesses, electronic intensive care unit (e-ICU) monitoring programs are suitable, as they allow nurses and physicians to remotely monitor around sixty to one hundred patients in ICUs from multiple hospitals. In the US, these programs are provided in several healthcare facilities, such as Sutter Health, Mercy Virtual Care Center, and Sentara Healthcare (Hollander and Carr, 2020).

A combination of telemedicine with robot technology was also found in the US. The Boston Dynamics' robot dog "Spot" was assigned to Brigham and Women's Hospital in Boston. Spot has a tablet where the head would have been, and thus the robot operator can communicate with patients and other healthcare personnel. These robots are deployed with a special payload in triage tents and parking lots to help hospital staff receive information of COVID-19 suspects and perform initial assessments (Mack, 2020; Simon, 2020).

The existence of robots which can navigate hospitals to monitor certain patients and exercise menial tasks such as delivering supplies and food would free up human doctors, nurses, and other medical personnel. Spot is a new model with deft footwork, which could navigate halls better compared to wheeled robots. This minimizes chances of getting stuck in hospital halls and doorways.

Boston Dynamics is also open-sourcing Spot's sensor codes to help other machines remotely interview patients (Simon, 2020). Theoretically, if this experiment is successful, more specialists can monitor patients from a safe distance and administer medical actions such as temperature taking or medicine deliveries. Reducing medical personnel exposure is important. It is noted that in the US alone, up to 100 workers from a single institution must undergo quarantine due to COVID-19 exposure, raising concerns for their workforce capacity. The company hopes Spot will eventually be able to collect vital signs from patients such as body temperature, respiratory rate, pulse, and oxygen levels to solve this issue (Mack, 2020).

There are still setbacks of using robots. Disinfection must be done periodically. Robots' fans may also spread viruses similar to human sneezes. However, Spot's case study has proved

that robot utilization can help to optimize the use of telemedicine.

Engineers at Boston Dynamics hope to enable Spot to use a thermal camera that can remotely measure patients' temperatures in the future. Strapping a UV light used for disinfecting hospital rooms is another idea that still needs further analysis as it will need a powerful but compact and safe power source (Simon, 2020).

In the developing countries, telemedicine is a key in providing health services. Governments and private entities have worked together to provide high-resolution telemedicine services using 4G and 5G signals that cover the entire globe. Affordability of connection is also important to ensure clinics and hospitals in remote areas can access telemedicine.

Specifically, for highly contagious diseases such as COVID-19, telemedicine also can be used to prevent the virus spread. Local health technicians can operate stethoscopes, thermometers, or even x-ray machines connected via Bluetooth, and then send the data to a pulmonologist to make a diagnosis. Therefore, patients can stay in quarantine and still receive health services.

Domain D: Human Space Flight

The human space flight domain has proven to have contributions to general health concerns and certain diseases. Resources and tools used in space flight bear more relevance to the COVID-19 pandemic than what was initially thought. This specific domain takes on the wide spectrum of technologies used in human space flight which may relate to other health concerns (Dietrich *et al.*, 2018).

Telemedicine is an element which intersects the use of technology in both healthcare and human space flight, despite falling under the satellite communication domain as previously explained. Both missions face similar issues, such as having low bandwidth connection leading to

weak signal, acquiring and maintaining a stable power source, assuring adequate data storage, requiring an intelligent software development and user training to ensure the availability of reliable human resources (Dietrich *et al.*, 2018).

A potential breakthrough comes from NASA. Their engineers at the Jet Propulsion Laboratory (JPL) in Southern California have developed Ventilator Intervention Technology Accessible Locally (VITAL), a new high-pressure ventilator tailored to treat COVID-19 patients (Good, 2020). In April 2020, NASA sought for expedited approval from the Food and Drug Administration (FDA) for VITAL via an emergency authorization, and the request was approved in May 2020. This system uses a fast-track approval process developed for crisis situations and takes just several days rather than months or years.

The whole space industry and space agencies have started to modify and apply technology for human space flight to help patients with COVID-19 and health workers (Naray, 2020). Engineers can modify technologies used for creating space suits and breathing devices for astronauts. Such alternatives can be applied to help patients who need ventilators and health workers who need extra protection due to their high exposure to the virus. The industry also has the capacity to produce both ventilators and special gears required (National Aeronautics and Space Administration, 2020; Porter, 2020).

Application of Space Technologies in Indonesia in Response to COVID-19

The use of space technology in Indonesia, whether for remote sensing, telecommunication satellites, or navigation satellites, has been oriented to support the achievement of the Sustainable Development Goals, the Sendai Framework, as well as the Paris Agreement. Over the last four years, the

Ministry of Health has been using space technology for telehealth and telemedicine to provide health services to 50 remote areas in Indonesia. They will push such ways to reach more remote areas.

For that goal, the Indonesian Government has invested in an infrastructure known as Palapa Ring and a sky highway (*tol langit*), with the ambition of connecting health centers, schools, disaster mitigation agencies, and other government institutions, including the ones located in remote areas throughout the Indonesia archipelago (PT. Palapa Ring Barat, 2016). The infrastructure includes optical cables, microwave signals, and 4G connection. The Government has also procured its own communication satellites and will sell the services to different government institutions.

In terms of disaster management, the Indonesian National Agency for Disaster Management has made use of space technology to support disaster management in Indonesia and in other ASEAN countries. Meanwhile, to anticipate climate change, space technology, particularly remote sensing, has been used to periodically monitor the condition of forests in Indonesia. For example, currently almost all provincial governments have space-based earth observation systems, as a result of collaboration between Lembaga Antariksa dan Penerbangan Nasional (National Institute of Aeronautics and Space of Indonesia, abbreviated as LAPAN) and provincial governments.

Article 29 of Indonesia's Government Regulation Number 11 of 2018 on Remote Sensing states the necessity of validating and calibrating remote sensing data to have accurate and dependable end results. Collaborations as mentioned in the above paragraph are important, and LAPAN as Indonesia's appointed focal point for space activities needs access to remote sensing data from its own satellites, other government institutions, private entities,

and foreign agencies to ensure better disaster management in the future.

Indonesia has also implemented telemedicine. The elucidation of Article 24 of Law Number 21 of 2013 on Space Activities includes telemedicine as a part of spin-off technology, referring to the benefits of space technologies for other industries. Considering how much Indonesia depends on this technology, the Indonesian Government has mandated LAPAN to master it.

Back in 2018, the Ministry of Health's Directorate General of Health Service launched Sehatpedia, an application aiming to disseminate accurate, credible, and trustworthy healthcare information to Indonesian society. Sehatpedia is supported by specialists from 33 hospitals who have the capacity to provide specific consultations for users (Indonesian Ministry of Health, 2018). It is featured with an interactive live chat for consultations, access to articles related to health care, the Directorate General of Health Service's health tracker, a website link for patient registration, and E-Policy.

The Indonesian Ministry of Health also built an application called Integrated Technology Telemedical for Medical Service (Temenin) to connect doctors, hospitals, and clinics to combat the challenges of equal access to medical services in rural areas. Technicians and general practitioners in small clinics will operate the machineries to perform certain medical actions such as radiology, electrocardiography (EKG), and ultrasonography (USG). Results would then be sent to specialists in bigger hospitals (Indonesian Ministry of Health, 2020a).

In 2018, the tele-radiology, tele-EKG, tele-USG, and tele-consultation were successfully used in smaller government clinics. Based on Article 2 of the World Health Organization International Regulation 2005 (WHO IHR 2005),

Indonesia also has the obligation to prevent, protect against, control, and provide a commensurate public health response to the international spread of disease in ways could restrict public health risks in the pandemic.

During the COVID-19 pandemic, these technologies can be modified to medical equipment that are possibly required to connect the clinics to pulmonologists working at larger hospitals in urban areas. Tele-consultation and applications mentioned previously also can be used to determine whether a patient should be referred to other specialists or not and to identify the right doctors in certain locations. There were over 700 general practitioners and specialists working with Temenin as reported in April 2020 (Indonesian Ministry of Health, 2020b), with 55 hospitals supporting 148 healthcare facilities (Indonesian Ministry of Health, 2020c).

Indonesia has also used the satellite communication technology domain to combat the COVID-19 spread. Using satellite communication, LAPAN through the LAPAN-A2/LAPAN-ORARI satellite has given public information on physical distancing and raised awareness of the importance of wearing masks when going outside (National Institute of Aeronautics and Space of Indonesia, 2020). Some of the campaigns are “Tetap Sehat, Tinggal di Rumah/Stay Healthy, Stay at Home” #LAWANCORONA/#FIGHTCORONA, “Stay Healthy at Home and Productive” #FIGHTCOVID-19, and “Wajib Pakai Masker/A Mask is a Must” #JagaJarak/Social Distancing #Stay@Home #FightCovid19.

CONCLUSION

Space technologies hold a role in advancing global health goals. They allow efficiency, tracking, surveillance, and disease-control planning. In the context of

COVID-19, space technologies have been proven to be invaluable in helping health care personnel and governments track the disease's sources and spread, and identifying where the most damage occurs. It also maintains daily activities such as communication and work afloat. Future developments in space technologies would possibly have an even bigger role, such as minimizing patient contact with medical personnel to minimize the virus spread.

Indonesia has used space technology through remote sensing, GNSS, and satellite communication although it is not as advanced as in some other developed countries. There is plenty of room for innovation and cooperation in order to encounter and mitigate the COVID-19 pandemic.

CONFLICT OF INTEREST

The authors stated that there was no conflict of interest with anyone for this article.

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