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Report on the United Nations/Islamic Republic of Iran Regional Workshop on the Use of Space Technology for Human Health Improvement

Hosted by the Iranian Space Agency (Tehran, 23-26 October 2011)*

I. Introduction

1. The prime objective of the Workshop was to promote awareness of the use of space technology applied to health care and review benefits of such applications as tele-health/telemedicine, mobile health, tele-epidemiology, and distance learning. Capabilities of satellite-based technology for the above applications have not been fully disseminated to the health-care providers and agencies that could be using them. The workshop contributed to closing this gap.

2. The present report describes the background, objectives and programme of the Workshop and contains recommendations made by the workshop participants. The report has been prepared pursuant to General Assembly resolution 64/86.

A. Background and objectives

3. Public health is the science and art of preventing disease, prolonging life and promoting health through the organized efforts and informed choices of society, organizations, public and private, communities and individuals. It is concerned with threats to the overall health of a community based on population health analysis. The population in question can be as small as a handful of people or as large as all

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the inhabitants of several continents (for instance, in the case of a pandemic). Public health is typically divided into epidemiology, biostatistics and health services. Environmental, social, behavioural and occupational health are also important subfields.

4. The focus of public health intervention is to prevent rather than treat a disease through surveillance of cases and the promotion of healthy behaviours. In addition to these activities, in many cases treating a disease may be vital to preventing it in other people, such as during an outbreak of an infectious disease.

5. With the use of space technology services, tele-health/telemedicine is receiving worldwide attention. It consists of computer and telecommunications (including satellite-based communications) technologies which can bring medical experts into virtual contact with patients in remote and rural areas, and thus, avoiding the costly relocation that also proves detrimental to their health.

6. Until recently mobile telemedicine's most important applications have been in ambulances and on ships. Both of these applications present time critical situations. Equal speed of diagnosis is the primary reason to monitor the vital signs of patients and provide forewarning of treatment requirements to the hospital.

7. In a disaster scenario, terrestrial communications can be the first to suffer from the direct effects of earthquakes, fires or flooding. In these situations, satellites remain the only reliable means of connection directly to the disaster area where communication is critical for diagnosis, patient treatment and activity coordination. Also, satellite links can be established in short periods of time.

8. There are about 1400 communicable diseases, and half of the world's population live in endemic areas. Public health and epidemiology, in particular, has become a hot topic recently, mainly because of the severe acute respiratory syndrome (SARS) crisis and the pending threat of pandemic influenza. Despite the advances of modern medicine, diseases like malaria, Dengue fever and even the plague still afflict millions of people each year, crippling some while proving fatal to others. Many of the diseases are spread through mosquitoes, which can cause widespread epidemics by infecting people or animals and then flying to other target. Malaria alone infects up to 500 million persons each year, killing almost a million.

9. Advances in satellite remote sensing, global positioning, geographic information systems and computer processing now make it easier to integrate ecological, environmental and other data for the purpose of developing predictive models that can be used in disease surveillance and control activities. However, capabilities of satellite-based remote sensing, navigation and location technology have also not been fully disseminated to the health-care providers and relevant institutions that could be using them.

10. Landscape epidemiology is a relatively new interdisciplinary approach that involves the characterization of eco-geographical areas where diseases develop. It can be understood as part of a second-generation application of remotely-sensed data where the target cannot be seen directly with satellite images. This is a holistic approach which takes into account relationships and interactions between the different elements of ecosystems under the assumption that the biological dynamics of both the host and vector population are driven by landscape elements such as temperature and vegetation.

B. Programme

11. In the area of tele-health/telemedicine, the programme of the Workshop addressed satellite-based: (i) TV and radio broadcasting that are inexpensive platform for delivery health-care education to distant locations; (ii) mobile communications that are the most promising means for reaching underserved and isolated areas; (iii) delivery in emergency situations; (iv) services for mobile objects at sea, in the air and on the land; and (v) satellite-based remote sensing and satellite positioning and location as tools for tele-epidemiology applications.

C. Attendance

12. A total of 139 participants from the following 11 countries attended the Workshop: the Republic of Belarus, the Kingdom of Bhutan, Germany, India, Iran (the Islamic Republic of), Lao PDR, Myanmar, Pakistan, the Philippines, the Republic of Korea and Spain. Representatives of the United Nations Resident Coordinator Office in Iran, UN Office for Outer Space Affairs, WHO and Asia Pacific Space Cooperation Organization (APSCO) also participated.

13. Funds allocated by the United Nations and the government of Iran through the Iranian Space Agency (ISA) were used to defray the cost of air travel, daily subsistence allowance and accommodations for 12 participants. The co-sponsors also provided funds for local organization, facilities and transportation of participants.

II. Summary of technical presentations

A. Tele-health/Telemedicine

14. WHO describes telemedicine as: “the delivery of healthcare services, where distance is a critical factor, by all health professionals using information and communication technologies for exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health providers, all in interests of advancing the health of individuals and their communities.”

15. The telemedicine goal is to improve health outcomes and provide clinical support by overcoming geographical barriers and connecting users who are not in the same location. It involves the use of various types of ICT. There are two basic types of telemedicine applications based on the timing of the information transmitted: (i) interaction between the individuals involved in real time (doctor-to-doctor and doctor-to-patient) and (ii) store-and-forward data exchange.

16. In developed countries, the majority of telemedicine services are focusing on diagnosis and clinical management. In developing countries and countries with limited infrastructures, telemedicine applications are primarily used to link health-care providers in local hospitals with specialists in referral and tertiary hospitals.

17. A WHO survey showed that: (i) 30% of responding countries have a national agency for the promotion and development of telemedicine; (ii) 50% of countries

reported that scientific institutions are involved in the development of telemedicine solutions; (iii) 20% reported having an evaluation or review on the use of telemedicine in their country since 2006; and (iv) teleradiology has the highest rate (33%) of established service provision. African, the Eastern Mediterranean and the South-East Asian regions have the lowest rates of national policy.

18. The most prevalent barrier of telemedicine services establishment is the perception that the cost of deployment is too high. In developing countries, in addition to high costs, there is underdeveloped infrastructure and lack of technical expertise. In developed countries there are legal issues related to privacy and confidentiality, competing health system priorities and perceived lack of demands.

19. The Ministry of Health and Medical Education (MOHME) of Iran, through its partnership with WHO, has upgraded a web-based influenza surveillance system. This system was piloted in Shahid Behesti University to be used in at least 10 districts of Tehran. Also in cooperation with WHO, MOHME developed a web-based Vaccination Supplies Stock Management (wVSSM) application to connect the central vaccine store to the regional, provincial and districts stores (435 vaccine storage stores are currently connected to wVSSM).

20. The Asia-Pacific Space Cooperation Organization (APSCO) is an inter-governmental organization operated as a non-profit independent body with full international legal status. Its objectives are: (i) to promote and strengthen the development of collaborative space programmes among its Member States by establishing a basis for cooperation in peaceful applications of space science and technology; (ii) to take effective actions to assist the Member States in such areas as space technology research and development, applications and training by elaborating and implementing space development policies; (iii) to promote cooperation, joint development, and to share achievements among the member States in space technology and its applications as well as in space science research by tapping the cooperative potential of the region; (iv) to enhance cooperation among relevant enterprises and institutions of the Member States; (v) to promote the industrialization of space technology and its applications; and (vi) to contribute to the peaceful uses of outer space in the international cooperative activities in space technology and its applications.

21. Potential tele-health applications need to be prioritized before their implementation because it is unlikely that resources will be available to implement all of them at the same time. Health-care authorities need to make a decision regarding which services to implement first considering: (i) the proportional difference between expenditures and savings over a five-year period; (ii) the evidence of the impact of telemedicine on travel patterns from remote and rural areas to metropolitan areas; (iii) how easy it will be to implement each particular telemedicine application.

22. Based on the fifth national development plan of Iran, the government has to establish a comprehensive public health service system in 2011 and make it quite active from the following year. Therefore, practical and clever actions throughout the country should be implemented in this regard.

23. After a successful establishment of the first academic e-learning programmes by Shiraz University in 2003 in Iran, sustainable telemedicine and tele-health systems have recently been developed and implemented among Shiraz Mother,

Child Hospital (main centre) and three other medical centres (Shiraz Shahid Rajaee Hospital, Gerash Hospital and Iranian Hospital in UAE). The Iranian Space Agency also plans to invest in implementing telemedicine systems in Iran.

24. The following challenges in expanding these systems are to be addressed: (i) the cost and quality of the current communications infrastructure, including satellite-based communications; (ii) the lack of appropriate legislation and regulations and financial support for developing such applications; (iii) the impact of restrictions on technology imports in improving public health and medical services; (iv) the needs for cultural and social programmes for better acceptance of new technologies by the experts and general public; and (v) better understanding of the cost-benefits of such applications.

25. It is estimated that car accidents claim three lives per hour in Iran which results in the annual rate of death of around 25,000 fatal cases and about 250,000 injuries. Car accidents are the second cause of death in Iran and the fourth highest cause of death globally. This is five times more compared to average figures in the region and 20 times higher compared to industrialized countries rates. The financial burden of medical care for car accident patients in the country is 70-100 billion rials annually.

26. Although telemedicine has generally been accepted as a useful technique for improving access to health services in developing countries as well as in Iran, for various reasons it has made very little progress. Strategies at national and international levels have not yet been able to facilitate telemedicine development properly. At the national level, efforts must be made to raise awareness of policymakers, health personnel and business communities about the benefits of telemedicine. Policymakers must also have a more open-minded attitude towards telemedicine. Overseas development assistance schemes must include telemedicine-provided health as an integral part of the development and promotion of health generally.

27. Potentially, telemedicine is able to improve the delivery of health care. However, one has to answer a very important question: is this health procedure/service/programme worth doing compared to other things one could do with the same resources? The perspective chosen may have a large impact on the cost-effectiveness results. For example, it appears that the cost-effectiveness of home telecare for older people and people with chronic conditions is uncertain. In addition, the cost-effectiveness for online-care in diabetes is also undetermined.

28. On the other hand, applications such as telestroke are more cost-effective compared to the usual model of care (the incremental cost-effectiveness ratio for telestroke over a person's lifetime is less than US$2,500 per quality-adjusted life year). Telemedicine is a cost-effective alternative for the delivery of outpatient pulmonary care for rural populations with limited access to subspecialty services. (US$335 per patient per year) compared to routine care (US$585 per patient per year) and on-site care (US$1,166 per patient per year).

29. In general, it makes no sense to say that telemedicine is or is not cost-effective. It can be said whether a particular use of telemedicine is effective for a particular condition in a particular setting. Cost and consequences of any telecare intervention must be identified before making any decision.

30. The total number of patients served in Iran by the Petroleum Industries Health Organization (PIHO) is 518,000. Out of this number, 336,000 are employed workers with their families and 182,000 are retired employees with their families. The primary medical system of PIHO comprises of the following centres: 63 for paramedical services, 70 for family medicine and 72 for occupational health. Its secondary health-care system consists of 18 specialized centres, 7 general hospitals and 3 specialized hospitals.

31. The cost of sending a patient to specialized hospitals in Tehran from other regions (travel, room and board, medical expenses and cost of replacement) is in the range of US$150-350. In addition, before establishment of PIHO-owned telemedicine system, the time span between the need and actual visit to a medical expert was an average of 14 days. After the system was established, this time span shrank down to a maximum of 2 days. A survey conducted showed that over 80% of patients were satisfied with tele-visits made.

32. Satellite technologies are a natural ally in public health emergencies in Iran for tracking the extent of disease outbreaks and natural disasters. Satellite-based remote sensing has even proven to be valuable in tracking environmental influences in childhood asthma. Satellite data are revealing pollution levels and other environmental factors where the children live to find out whether these factors might be triggering asthma attacks. Children can then be given asthma therapy to protect them from the effects.

33. According to the constitution of the Kingdom of Bhutan, a free health-care system is provided. A national health project is now being implemented. It is divided into two parts — a SAARC telemedicine project and a rural telemedicine project. The South Asian Association for Regional Cooperation (SAARC) telemedicine project provides a forum for the specialists at the national referral hospital to share/consult on cases with specialists in the SAARC region as well as keep abreast of the latest developments in their area of expertise. The rural telemedicine project provides a forum for the doctors at remote districts to teleconsult cases with specialists at the national referral hospital.

34. The Health Help Centre initiative, under the programme for accelerating Bhutan's socio-economic development, provides the following services: emergency response, a health-care helpline, medical counselling, a health-care information directory, a complaint logging system, and a hospital information system. A comprehensive patient record from registration, doctor notes, prescription, lab results, in-patient records to administration services is being created during visit to the hospital.

35. The Department of Space Technology (DST) was established in April 2008 under the National Authority for Science and Technology within the Prime Minister's Office in Lao PDR. DST is mandated to implement the overall management and administration of space technology development. DST consists of 3 Divisions: (i) the General Affairs Division; (ii) the Space and Terrestrial Affairs Division; and (iii) the Service Management Division. Among various functions of DST, the most important one is the promotion of space technology applications for socio-economic benefits including RS, GIS, GPS, tele-education, and tele-health.

36. SUPARCO, being the national space agency of Pakistan and having experience in satellite communications, has initiated a satellite-based telemedicine network as a

pilot project which has been successfully established. Very Small Aperture Terminal (VSAT) technology has been selected to provide broadband connectivity for live videoconferencing, transfer of high quality biomedical images as well as other activities which best meet the requirements of medical experts. Two medical centres have been connected via a transponder on Paksat-1 satellite: one at the Jinnah Post Graduate Medical Centre (JPMC) in Karachi as a hub and the other one at the Shikarpur civil hospital as a remote site.

37. For better utilization of satellite-based network infrastructure in telemedicine applications, including tele-consultations and tele-trainings, SUPARCO has also established a joint venture with JPMC.

38. Due to a rising chronic disease prevalence rate influenced by a high number of aged population and disasters in the world, it is estimated that the efficiency of medical services provided by hospitals will decrease. To address this problem a U-Health technology should be developed. U-Health may be described as a new paradigm of medical industry, and can be defined as prompt accessibility to health management and medical service anytime.

39. Telecare via satellites may be implemented to provide self-management services for the patients located far away from hospitals. Major services of telecare may be comprised of telemedicine, health-care management, tele-monitoring, tele-emergency among others. Iranian and overseas medical experts can participate in providing various virtual services. For the purpose of connecting these doctors, an online tele-medical centre can be established.

40. Combining these services, it is proposed to establish a telecare system for emergency situations, a health-care platform and a Personal Health Records (PHR) database to provide personalized contents and self-management via a satellite-based communications infrastructure.

B. Mobile Health

41. Priorities for the 21st century ought to be set based on emerging dominant trends in health care, including the shift towards shared or integrated care, in which an individual's health care is the responsibility of a team of professionals across all levels of the health-care system hierarchy. Mobile wireless technologies are increasingly growing in developing countries. There has been much new research and developments in this area which have shown the potential impact of the mHealth. Rapid advancement in technologies, ease of use, and falling prices of software/hardware make mobile technologies an appropriate and adaptable tool to bridge the digital divide. Current mHealth devices are able to continuously monitor an individual's pulse and blood pressure, detect breathing abnormalities associated with bronchial asthma and other chronic respiratory system diseases.

42. Sleep disorders also seem to be one of the main areas in which there is considerable experimentation with mHealth techniques. Expensive telemedicine platforms and network media act as a barrier in adoption of this technology in health system in low-resource environments. Developing countries require low-cost, sustainable telemedicine solutions for the local delivery of primary health care at the door step of each individual. A low-cost portable telemedicine kit called

mHealth4U® was designed and developed to address these needs. The kit was developed at the School of Telemedicine & Biomedical Informatics in India as part of research strategy on the development of a low cost tele-health delivery tool.

C. Tele-epidemiology

43. In the last decades, numerous studies have demonstrated usefulness of geographic information systems (GIS) in furthering epidemiological knowledge of the various diseases transmitted by vectors, mainly arthropods, such as malaria, leishmaniosis, trypanosomosis, Chagas disease or lymphatic filariosis. Likewise, other studies have shown this methodology to be valid in the epidemiological study of snail-borne parasitic diseases, including schistosomosis and fasciolosis. These projects include an analysis of climatic as well as remote sensing data, mainly NDVI, land cover and land use.

44. Climate plays an important role in determining the seasonal and geographic distribution and frequency of many parasite species. Furthermore, climate change and natural disasters' effects have to be considered particularly in terms of the various transmission cycles of infectious agents, those transmitted directly and those transmitted by other living beings, especially invertebrates. Studies, including prediction models, concerning the epidemiology and transmission of human and animal parasites have to incorporate the analysis of climatic alterations in the short run as well as in the long run.

45. To shed more light on the effects of climate change and natural disasters on the epidemiology of parasitic diseases, the main results of a multidisciplinary group of the Universidad de Valencia in Spain carried out some research concerning these topics. Fasciolosis has been well studied in some parts of the world, especially in human and animal endemic areas, such as the Andean mountain range, the Nile Delta and the province of Gilan in Iran. Moreover, this parasitic disease influenced by El Niño-Southern Oscillation and other cyclic climatic events has also been studied. As climate change and natural disasters are expected to influence the epidemiology of human and animal parasites, modifying their transmission patterns and geographical distribution, parasitic diseases have to be included in future research on human and animal health effects expected by new trends of global climate.

46. Earth Observation (EO) technologies are quickly being developed in recent years, and with applications spreading into more and more areas. For human health improvement, earth observation data have unexpected effects: (i) using earth observation data, one can easily know the environment around and select safe living areas; (ii) combining EO data and GIS, one can locate the sites of infectious diseases outbreak, then model a spatial diffusion and propose control measures; (iii) combining EO data and GPS, one can mark the exact location of a patient and choose the best path for rescue.

47. Cases of visceral leishmaniasis (VL) are frequent in several parts of Iran. Examples of areas with reported VL include the Meshkin-Shahr district in the Ardabil province as well as the Azar-Shahr district in the province of East Azerbaijan in the North. Cases are also reported from the Firuz-Abad district in

the Fars province in the South and in some nomadic communities in other parts of the country.

48. The Meshkin-Shahr district, a rural, mainly agricultural area, is one of the most important endemic zones for VL in Iran. Out of 1,050 cases of VL occurring in Iran during the period 1985-1990, 800 (76%) originated in this district. In addition, in contrast to other parts of Iran, people in the north-western provinces have a close relation to dogs, which are not only used for shepherding and guarding but also kept as pets.

49. Records of human and animal cases in the study area from the period 2003-2008 were retrieved for eight villages from primary health-care files. Meteorological data, including relative humidity, annual rainfall, the state of local rivers, elevation and the number of days in the year colder than 0° C (freezing days) were retrieved from the Iranian Atmospheric Science and Climate Research Centre.

50. Throughout six years in three observation stations located in Manila, climate variables (temperature and rainfall) were correlated with total hospital admissions for Dengue fever, malaria and cholera from sentinel hospitals. Analysis reveals that a remotely sensed temperature and rainfall data may be used as input for an outbreak prediction of Dengue fever, malaria and cholera. Rainfall, however, is not suitable for the early warning of cholera.

51. Using climate variables, space technology application is unquestionably advantageous for the early warning of an outbreak of some diseases and in identifying the most vulnerable areas. The extent of applicability of space technology in human health improvement should be studied extensively, and the possibility of information sharing especially for developing countries should also be taken into consideration.

52. Rheumatoid arthritis and osteoarthritis are widespread problems. A major technical challenge is that articular cartilage has a limited regeneration capacity and cartilage defects have a limited capacity to heal; only a temporary repair tissue will be created in the defect space. This repair tissue most often lacks the biochemical properties and mechanical resilience of the original tissue, thus contributing to further problems. A new approach to this problem could be a co-culture of primary undifferentiated tissue cells with pluripotent mesenchymal stem cells (MSCs).

III. Observations and recommendations

A. Observations

53. As of now, the idea of space technology applications to public health services has significantly evolved.

54. In the area of tele-health, public health authorities can use satellite communications for: (i) delivering various health expertise to remote locations; (ii) providing training and distance learning; (iii) receiving large amounts of secured data in case of an emergency response, when ground-based infrastructure is not available or cannot be used.

55. Mobile health (mHealth) involves the use of mobile devices through wireless technologies in health-care applications. Its applications vary greatly by region. In developing countries, mHealth applications address more remote diagnoses in rural areas where health-care services are limited as well as education and tracking disease outbreaks. In developed countries, mHealth services focus more on improving health care through prevention and wellness programmes as well as improved efficiencies. Everywhere, health-care institutions are now recognizing more and more the value of improving care and clinical reach via mHealth technologies.

56. Another different type of satellite technology application in public health relates to the need to obtain accurate earth observations of physical features for operational considerations. In this area, the availability of current earth observation images featuring visible land characteristics of a region is central. This can be of paramount importance when providing health emergency services in the presence of a pending hazard threatening a population or after a natural disaster has happened.

57. Both health investigators and public health-care providers have recently made more efforts in considering geographical factors as determinants of a wide range of diseases and health conditions. This, along with progress in the development of space technology applications, has resulted in a greater ability to integrate this information into health surveillance and population data either for operational need, decision-making or scientific discovery.

58. Although satellite technologies have been applied in environmental science for many years now, it is still considered by many as an emerging field of application in the area of public health. In view of the core public health functions and the set of tools that public health organizations utilize, the potential benefit of the various satellite technologies to improve public health services is tremendous. In delivering these services, one of the main applications of space technologies relates to the field of satellite communications.

59. Finally, satellite technologies can be used in the global positioning, measurement or characterization of dynamic environmental and population events (sick populations, habitat of vectors, reservoirs, and identification of risk factors) for surveillance, risk assessment or epidemiological research. This latter area relates to the domain of landscape epidemiology and tele-epidemiology and is a domain of rapid evolution in its application, integration and acceptance in public health.

B. Recommendations

60. WHO recommendations to member States to facilitate telemedicine development are: (i) consider a long-term strategic plan for its development and implementation; (ii) establish a national body for telemedicine, supported by the Ministry of Health (MOH); (iii) adopt local contexts policies by engaging other stakeholders at all levels: community, health professionals, academic institutions, health administrations and policymakers; and (iv) support and encourage telemedicine research and evaluation initiatives.

61. Member States should: (i) invest in cost-effective, multi-purpose telemedicine solutions; (ii) maximize affordability and sustainability of infrastructure

development (in partnership with private and NGO sectors including legally binding agreements); and (iii) convene a forum with the MOH, ICT sector, education community and other stakeholders to discuss how to improve health-care delivery.

Participants of the workshop also made the following recommendations:

62. Establish a regional telemedicine research centre in Asia. Both APSCO and Iran fully support this idea and are ready to host this regional organization in Iran.

63. Review available cost-effective satellite-based technologies relevant to the specific health-related needs in Iran and the potential of their contribution to the improvement of the health of the Iranian population including the development of an e-health/telemedicine strategy for Iran and a national tele-health network project development.

64. Establish a national task force/working group including experts from the ministry of health, medical institutions, the Iranian space agency and the ministry of telecommunications.

65. Put an emphasis on the organization of training courses in tele-epidemiology and GIS as well as on access to remote sensing data for human health improvement (in particular, for rural areas of developing countries). For that, space technology applications for the diagnosis and treatment of tropical diseases should be considered as priority in view of the increasing tele-epidemiology use in forecasting disease outbreaks after natural disasters, climate change or other climatic events.

IV. Conclusions

66. Significant progress in space technology development and its applications for human health has been achieved over the past decade. Important benefits have already been realized from several initiatives in developing countries. However, most projects have been at the proof of concept or demonstration stages. Frequently, they are not fully integrated with local needs, resources and infrastructure. Most of the time, external funding is required to keep projects alive.

67. Future and more comprehensive use of space technologies in public health, and in particular in tele-health, will depend on the availability of cost-effective and competitive satellite-based or hybrid communications systems in comparison with the land-based telecommunications.

68. In tele-epidemiology, the satellite-based remote sensing data products should be improved in their spectral, spatial, and temporal resolutions. Then, they will allow better exploration of risk factors and health hazards beyond the current capabilities. Incorporation of these remote-sensing data into health surveillance and population-based information will result in an increased awareness by public health officials of the benefits of the applications of space technologies and contribute to better training of health-care providers in using space-based products.