United Nations Commission on Science and Technology for Development
Inter-sessional Panel 2020-2021
18-22 January 2021
Geneva, Switzerland

Issues Paper

on

Using science, technology, and innovation (STI) to close the gap on SDG 3, good health and well-being

Advance Unedited Draft

NOT TO BE CITED

Prepared by the UNCTAD Secretariat[1]

11 January 2021

[1] This draft was prepared by the Science, Technology and Innovation Policy Section of the Division on Technology and Logistics of UNCTAD. Contributions from the Governments of Austria, Belgium, Cuba, Ecuador, Finland, Islamic Republic of Iran, Kenya, Latvia, Portugal, Romania, Russian Federation, Switzerland, Thailand, and Turkey as well as from WHO, ECLAC, ECE, ESCAP, ESCWA, ITC, ITU, UNIDO, UNOOSA, UNWOMEN, WIPO, and International Vaccine Institute (IVI) are gratefully acknowledged.

Table of Contents

List of Boxes

Introduction

Innovative approaches to solve health problems are needed to complement traditional good practices in the health sector. In WHO's constitution (1946), health is defined as "… a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." This paper highlights that the whole spectrum of science, technology, and innovation (STI) can make a significant contribution to the achievement of SDG3 to "Ensure healthy lives and promote well-being for all at all ages" in all countries and esp. low and middle-income countries. This paper focuses on what science, technology and innovation actors can do to support health, complementing the efforts of those in the healthcare and other relevant sectors. This paper is not focused on health systems, but the scientific innovation systems that can make healthcare innovations and delivery more effective, efficient, and inclusive.

While STI contributes to the health sector overall, it plays a particularly important role in strengthening the capacity of all countries, in particular developing countries for early warning, risk reduction and management of national and global health risks as described in SDG 3-D. Data science, biomedical science and engineering and other technologies can broadly transform health and medicine and specifically support countries and regions in their responses to emerging health crises as well as in their preparedness for future threats. Beyond specific technological innovations, STI policy advice, diplomacy, and international cooperation also play a prominent role in current and future infectious disease preparedness and response. The Report explores experiences about using STI to strengthen health outcomes as well as approaches to regional and global STI cooperation in this field.

This paper argues the following points:

- Healthcare, as framed by SDG 3, is a key component of the global development agenda. Development is hard to realize and sustain without a healthy labor force. Persistent challenges and COVID-19 pandemic threaten progress on the achievement of these goals by 2030. Although there are many elements needed to ensure health lives for all, STI is a critical contributor to the development and delivery of healthcare innovations.
- STI can make a critical contribution across all areas of health. This paper focuses on 3 areas of concern for the global development community: primary health care, neglected diseases of the poor, and infectious disease outbreaks. STI is conceived broadly to include not only scientific and technical innovations but also well-established "low-tech" solutions as well as organizational and social innovations applied in healthcare.
- New technological developments in AI, digital health, gene-editing, blockchain and other areas can advance our efforts in achieving SDG3. However, these new technologies also raise critical concerns about privacy, security, accuracy of AI in healthcare, and the digital divide.
- The effective application of frontier or well established STI tools in healthcare requires national capacities for healthcare innovation. Key areas of policy consideration include investments in research, human capital and infrastructure, support for R&D commercialization, and a whole-of-government and multisectoral approach.
- Global health requires global partnerships to support national actions and international efforts in combating disease. Key areas for consideration include supporting national innovation ecosystems, improving the accessibility of health innovations, and building/strengthening multilateral and multi-stakeholder platforms for cooperation, knowledge sharing and standards-setting.

Chapter 1 investigates applications of STI in three primary healthcare, diseases of poverty, and health emergencies and infectious diseases. Chapter 2 focuses on the promise and critical considerations of frontier technologies (i.e., AI and digital health, space technologies, blockchain, etc.) for shaping the future of healthcare delivery. Chapter 3 analyses the key constraints and policy options at the national level to harness innovation for SDG3. Chapter 4 discusses global cooperation to strengthen national health innovation ecosystems, more equitable share the benefits of health technologies, and strengthen multilateral cooperation.

I. Applications of Science, Technology, and Innovation in Healthcare

Science, technology and innovation (STI) accelerates progress along seven accelerator themes identified by WHO's Global Action Plan for Healthy Lives and Well-being for All, especially in primary health care (including maternal and child health), diseases of the poor, and disease outbreak responses (including the COVID-19 pandemic).[2] This chapter will focus on the role of STI in addressing these three themes in the global action plan and analyze the challenges and policy issues that must be addressed to harness STI in these respective areas.

1. Primary Healthcare

WHO defined Primary health care (PHC) in the Declaration of Alma-Ata as "essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination".[3] Specifically, Alma-Ata Declaration has outlined eight essential components of PHC, including: (1) Health education on prevailing health problems and the methods of preventing and controlling them; (2) Nutritional promotion including food supply; (3) Supply of adequate safe water and sanitation; (4) Maternal and child health care; (5) Immunization against major infectious diseases; (6) Prevention and control of locally endemic diseases; (7) Appropriate treatment of common diseases and injuries; and (8) Provision of essential drugs. The declaration also set up core principles of primary health care including accessibility, public participation, health promotion, use of appropriate technology and intersectoral cooperation.

STI are important components of changes in primary health care in all the essential components and are crucial for its principles. Apart from providing the new breakthroughs for patients in treatment (components 7, 8), prevention (5, 6, 8) and lifestyle (1, 2, 3), STI has an important mission of improving the coverage and ensuring the access to it for all groups of people thus reducing existing inequalities and fulfilling the primary health care principles. Research and development, innovation and access as well as data and digital health can help deliver effective primary health care (see Digital Solutions for Primary Health Care in Chapter II), which is the foundational component of SDG3 targets and is associated with better health outcomes, best cost efficiency, and improved equity.

<u>Maternal and child health</u>

Every year, more than five million children die before the age of five due to preventable or treatable causes, most of them in developing countries. New technologies combined with rapid tests can improve diagnosis and management of sick children and reduce health costs.[4] One

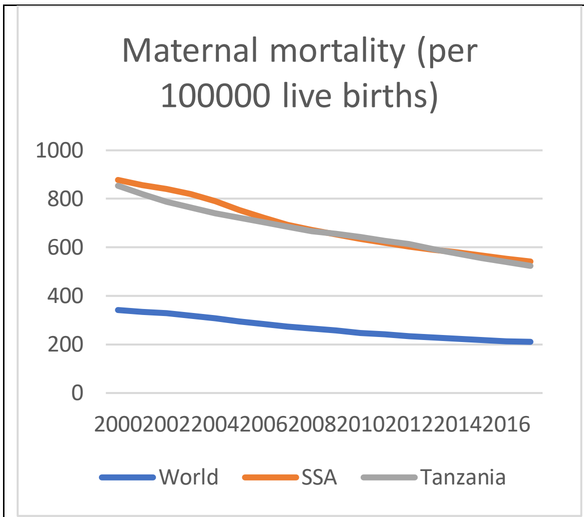
[2] https://www.who.int/initiatives/sdg3-global-action-plan
[3] https://www.who.int/docs/default-source/documents/almaata-declaration-en.pdf?sfvrsn=7b3c2167_2
[4] Contribution from the Government of Switzerland

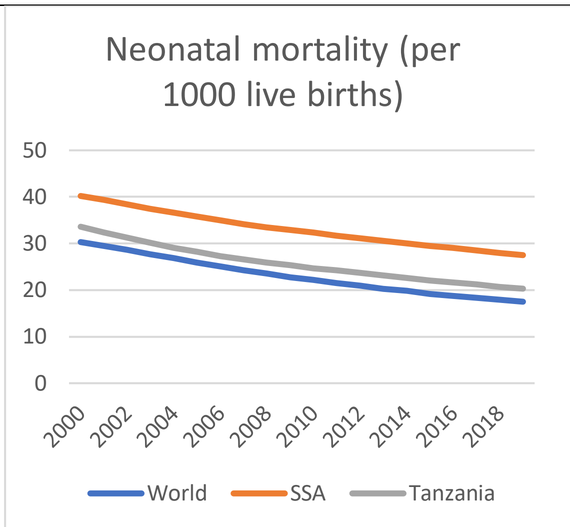
area of active development is the use of diagnostics in prenatal screening of congenital defects. The National Austrian Newborn Screening Program for inherited metabolic and endocrine disorders has been implemented in Austria since the late 1960s. It was introduced by the Federal Ministry of Health, the Federal Ministry of Education, Science and Research and the Medical University of Vienna, and it is located at the Department of Pediatrics and Adolescent Medicine. Most children are born healthy, but there are rare congenital diseases, which cannot be detected in newborn infants from external indications. Newborn screening identifies conditions that can affect a child's long-term health or survival. More than 100 children are identified in the screening program in the first days of life every year. Early detection, diagnosis, and intervention can prevent death or disability and enable children to reach their full potential. In Austria, newborn screening is a collaborative effort between several public health departments and hospitals e.g. in Vienna, Graz, Innsbruck, and Salzburg. Newborn screening can save babies' lives and help them begin life healthy.[5]

In Cuba, prenatal detection of congenital defects is carried out as part of the National Maternal and Child Care Program. Through the quantification of alpha-fetoprotein in maternal serum, this program has offered pregnant women and their partners means by which serious congenital defects in the fetus can be confirmed.[6] Control and monitoring of the vertical transmission of HIV, syphilis and hepatitis B in pregnant women and their partners is conducted by the National Health System (SNS). As a result of these efforts, the World Health Organization in 2015 designated Cuba as the first country in the world to eliminate mother-to-child transmission of HIV and syphilis.[7] In some African countries, AI has been deployed to mitigate the high levels of maternal and child mortality (see Box 1).

Box 1: AI for maternal health care in Zanzibar

Most sub-Saharan countries face high levels of maternal and child mortality (542 deaths per 100000 live births and 27 deaths per 1000 live births correspondingly in 2017). Zanzibar (Tanzania) faces similar challenges (see charts below) in part because of limited access to emergency obstetric care, delays or inability to seek care, and biological and environmental risk factors that remain undetected and unprevented.





[5] Contribution from the Government of Austria
[6] Contribution from the Government of Cuba.
[7] Contribution from the Government of Cuba. For more information on WHO's validation, please see: https://www.who.int/mediacentre/news/releases/2015/mtct-hiv-cuba/en/.

One promising way to improve effectiveness and efficiency of service delivery of maternal, new-born and child health is predictive analytics and machine learning. D-tree International has been working with Zanzibar since 2011 on the project, aiming to personalize and improve maternal, new-born and child health in Zanzibar by integrating predictive analytics into the national digital community health system by using machine learning. It built a model for perinatal risk assessment based on primary data from over 40,000 pregnant women, using geospatial data from drone images, anonymized telecommunications data and mobile money transactions and GPS coordinates for health facilities and villages to take account for various risk factors.

D-tree has created in the "Safer Deliveries" program which allows community health workers (CHW) to conduct home-based visits with families guided by a mobile application. The CHWs create personalized birth plans, identify danger signs, and link women and families with health facilities. Data from the system is used by program managers and supervisors to improve quality and modify the system in a continuous feedback loop. The program has consistently shown 50% increases in facility delivery rates and four-fold increases in postpartum follow-up. This project is supported by the Zanzibar Ministry of Health and will equip over 2,000 community health workers with mobile apps and support them as they provide home-based services to pregnant women and children under 5.

Source: UNCTAD Secretariat

Digital technologies can also play a role in access to information about reproductive health. The NGO PCI Media provides multimedia communication tools and aids for health care workers in charge of sensitization campaigns on sexual and reproductive health and rights (SRHR) targeting teenagers. Local languages and the local cultural context are used when producing the content. Specific attention is given to reaching teenagers living with a disability or teenagers who are difficult to reach. Another project implemented by NGO CUAMM is part of a programme to improve sexual and reproductive health in adolescents and women with a focus on enhanced access to contraception, HIV and STD prevention and treatment through tailored interventions in schools, communities and health facilities. The target groups (teenagers and women) are reached through their schools, the local health centers or their local community structures. For teenagers, the objective is to improve health care and health information, with a focus on SRHR, whereas for women, the objective is prevention and treatment of specific female problems (fistula, etc.) The project is implemented in Mozambican districts of Tete city, Moatize, Nhamayabue and Mutarara. Besides supporting schools, local health care centers and local communities, the project mobilizes a network of activists, peers and community actors in order to reach teenagers through targeted SMS messages. The project should reach 200,000 teenagers and young adults in the above-mentioned districts (which comprise approximately 30% of the total population).[8]

In addition to prenatal care and reproductive health support, digital technologies can help improve the health of children and reduce unnecessary antibiotic prescriptions in low resource settings. The DYNAMIC research project, implemented in Tanzania and Rwanda, has the objective of improving the quality of care for children (0-12 years) in low-resource settings by implementing a novel point-of-care clinical algorithm (ePOCT +) that helps guide and train health workers in the diagnosis and management of sick children. ePOCT is a technological

[8] Contribution from the Government of Belgium

innovation designed to create sustainable, system-wide contributions, including health worker training, reduction of antibiotic prescriptions and the systemization of data collection, management and use. Expected outcomes of the projects are: (1) integrated management of children with acute illnesses at primary care level is improved; (2) The national health information system for disease surveillance and early epidemic detection is enhanced; (3) Clinical algorithm are improved and continuously adapted to geographical and seasonal variations using machine-learning; (4) Antibiotic drug pressure in the community is decreased; and (5) The environment for sustainability of electronic clinical decision support algorithms and framework for larger-scale implementation is supportive. ePOCT shows potential for scale-up in other settings as the digital algorithm tool developed will be flexible along the IT and medical dimensions. lt will be based on an open software that can be interfaced with any digital platform and can be adapted to new guidelines, modified at any time to take into account health system constraints such as stock-outs, and to integrate changes in diseases transmission and epidemics. At the end of the project, the Rwandan and Tanzanian national governments, as ultimate owners and users of ePOCT + and its data, should have the necessary tools for further national scale-up.[9]

Gender-Responsive Innovation for Health[10]

Ensuring inclusiveness of health innovations for women and girls and vulnerable communities is critical for ensuring that health innovations leave no one behind. Science, technology, and innovation can support the fight against gender-related health inequities. This section will focus on interventions to harness ICTs and social media for HIV information and agenda-setting campaigns, to build innovative capacities for women and girls in health-care settings, and to benefit from frontier technologies like blockchain. Mobile technologies can support strategic opportunities for adolescent girls and young women to engage in key agenda-setting forums on issues like HIV.

In 2015-2016, UN Women's "Engagement + Empowerment = Equality" initiative in Malawi, Kenya and Uganda mobilized over 1,000+ adolescent girls and young women champions, including 250 girls living with HIV. Young women were involved in the design and validation of national assessments on the status of HIV amongst adolescents and youth. The initiative included online and face-to-face mentoring, peer support, including WhatsApp support groups and social media outreach to thousands of other young women and girls (IPPF 2016).[11] The potential of innovative solutions offered by digital technologies should be further explored to mobilize and provide young women and adolescent girls with comprehensive HIV information, particularly in rural areas. In Ethiopia, Mozambique, South Africa, Tanzania and Zimbabwe, UN Women has increased knowledge and capacity of women living with HIV to prevent COVID-19, including through disseminating accurate information via community radio, social media and online peer support groups. In Guatemala, UN Women conducted a social media campaign aimed at spreading accurate and up-dated information about COVID-19, targeting women living with and affected by HIV. Messaging includes encouraging women to continue HIV treatment and where they can access HIV care and services for survivors of violence.

[9] Contribution from the Government of Switzerland
[10] Contribution from UN Women
[11] https://nam10.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.ippf.org%2Fnews%2Fend-gender-based-violence-and-hiv-ensure-equity&data=02%7C01%7C%7C98f4d3765d714b60bb4608d85e3676c3%7C2bcd07449e18487d85c3c9a325220be8%7C0%7C0%7C637362935296570619&sdata=tMbMlgXcoASxcprdgC4vIb%2FHrQAFPomdm%2Bf0itZE1Uo%3D&reserved=0

International efforts can support capacity-building for women and girls to serve as innovators in health-care settings. For example, in Liberia, through engagement with the H6 partnership, women were trained as solar engineers and equipped 37 rural maternity waiting homes and labour rooms with solar lighting systems (solar suitcases) as a reliable source of portable power system. The solar power provides much needed electricity in emergency cares. Women's participation in communities as promoters of health and well-being can be the innovation to transform societies. In 2019, UN Women convened a hackathon in Tajikistan to generate innovative ideas to support women living with HIV. The hackathon brought together more than 60 HIV experts, IT specialists, and representatives from the Tajikistan Network of Women Living with HIV, youth organizations, government agencies, the media, and international NGOs. As a result of a competition, three proposals were identified for further development: a website to mitigate stigma and discrimination against women living with HIV in employment, a start-up project to improve professional skills and personal development of women affected by HIV, and a mobile application to promote access of women living with HIV to healthcare, legal, psychological and social services.[12] UN Women also supports community led innovations and responses by investing in women's organizations to innovate solutions suited for their own communities. In the Zika response UN Women supported "situation rooms" where women community leaders met to discuss the impact and suggest policy solutions curb the epidemic.

New and emerging technologies like blockchain can support women's access to health services. UN Women in Jordan continued to provide direct cash-assistance to Syrian refugee and vulnerable Jordanian women through its blockchain technology in partnership with the World Food Programme. The beneficiaries of UN Women's support, through the cash assistance have been using funds to purchase medicine and medical supplies for themselves and their dependents. In some cases, they saved the funds to facilitate private-based medical services for their dependents when it was not covered by the medical facilities in the camp. The BlockChain technology is under WFP's umbrella for cash-based intervention programmes. UN Women partnered with WFP to tailor and customize the system specifically for the UN Women's cash for work programmes.

Traditional Medicine and Indigenous Knowledge

One area of interest in many countries is the use of traditional medicine and indigenous knowledge systems as a mechanism for extending access to primary healthcare. The 2010 STI policy review of Ghana undertaken by UNCTAD looked at promoting innovation in traditional and herbal medicines in Ghana.[13] THM is an important part of health service delivery in Ghana and provides access to affordable medicine outside of the formal health system. The ratio of medical doctors to population at the time was low, and it was estimated that 60 % of the population used THM as part of health care in the country. Development of THM could therefore help to ensure more inclusive health coverage in the country, especially among populations that cannot access modern medical services and medicines. It could at the same time help to create new export products for the West Africa region.

The challenges in developing THM into an industry included a low level of R&D on THM in the public sector or firms, a low level of testing of THM products (especially beyond testing for safety), the limited number of testing centers in the country, the small size of most

[12] https://eca.unwomen.org/en/news/stories/2019/05/tajikistan-hackathon-yields-innovative-ideas-to-support-women-with-hiv

[13] UNCTAD, 2011, Science, Technology and Innovation Policy Review : Ghana, UNCTAD/DTL/STICT/2009/8.

producers, the difficulty in investing in upgrading of production processes due to small size and lack of access to finance, low quality packaging and labeling, a limited supply of raw medicinal plant materials used for producing THM products, limited policy support for THM or integration of THM into the formal health system, a lack of protection for indigenous traditional knowledge used in THM production and a lack of knowledge about the size of the potential domestic and export market for THM products. The review suggested remedial policy actions to address many of these challenges, including information-based policy development, regulation, and R&D coordination.[14]

2. *Poverty-related diseases*

Poverty-related diseases – like malaria, HIV, and TB – tend to receive little financial support. For example, by the end of the first decade of the 2000s, only 10% of research was devoted to 90% of global disease burden.[15] Remote sensing technologies can aid in the fight against infectious diseases in resource-poor contexts while international companies and agencies can support early-stage R&D and access to technologies and treatments.

Remote sensing has and will continue to play a role in infectious diseases that disproportionately affect low- and medium-income countries. The eradication of wild polio in Africa was buttressed by mapping exercises based on high resolution satellite imagery in West Africa.[16] Meningococcal meningitis is a devastating epidemic disease in Africa, affecting the lives of individuals and communities in the "meningitis belt" of Africa, a sub-Saharan zone extending from Senegal to Ethiopia. Neisseria meningitides, the causal agent for the bacterial disease, is transmitted through respiratory droplets throughout the year, but the climate, notably hot, dry and dusty conditions, irritating the throat, appears to be favourable for invasive disease and associated epidemics. Furthermore, the timing of the epidemic year and the spatial distribution of disease cases throughout the "meningitis belt" strongly indicate a close linkage between the life cycle of the causative agent and climate variability. Integrating the environmental knowledge in decision-support tools can assist health officials in predicting epidemics and devising vaccination strategies, and remote-sensing technology plays a key role in providing information on absolute humidity, absorbing aerosols, rainfall and land cover and other environmental influences relating to the epidemics. [17]

International efforts like the European and Developing Countries Clinical Trials Partnership (EDCTP), established in 2003, are a response to the crisis provoked by the three main poverty-related diseases (HIV/Aids, tuberculosis, and malaria). EDCTP emanates from Article 185 of the Lisbon Treaty, and aims at promoting an integrated approach to clinical research towards prevention and treatment of those diseases, particularly in Sub-Saharan Africa, the worst affected region in the world. EDCTP goals are accomplished through manifold means. The major one is through the development of research projects and other activities that emanate from the calls for proposals launched by the EDCTP secretariat, mostly in linkage with other funders. However, they are also achieved through projects and activities implemented under the auspices of other funding schemes, including national calls.[18] In addition to research

[14] Although the STIP Review was published in 2011, the issues outlined in this section are still relevant for the Ghanaian healthcare system and also applicable to the situation in other African countries. An updated study on THM in Ghana is available at: Essegbey, G.O. and Stephen Awuni (2016) "Chapter 5: Herbal Medicine in the Informal Sector of Ghana", in Erika Kraemer-Mbula and Sacha Wunsh-Vincent (Eds.) *The Informal Economy in Developing Nations – The Hidden Engine of Innovation?* Cambridge University Press, pp. 194 – 227.

[15] https://www.who.int/intellectualproperty/submissions/InternationalPolicyNetwork.pdf

[16] https://www.geospatialworld.net/article/digitalglobes-satellite-imagery-polio/

[17] Contribution from UNOOSA

[18] Contribution from the Government of Portugal

institutions, the private sector can positively contribute to the diseases of the poor. For example, GSK's major laboratories in Tres Cantos, Spain were converted into a profit-exempt laboratory that focused only on diseases in the developing world, including malaria and tuberculosis.[19] Furthermore, efforts like WIPO Re:Search can also play a role in harnessing R&D in the fight against neglected tropical diseases, malaria and tuberculosis (see Box 2).

Box 2: Making IP available for Neglected Tropical Diseases, Malaria and Tuberculosis

In 2011, WIPO and the non-profit organization BIO Ventures for Global Health (BVGH), formed WIPO Re:Search -- a public-private initiative that supports early-stage research and development (R&D) in the fight against neglected tropical diseases (NTDs), malaria, and tuberculosis. WIPO Re:Search harnesses the power of public-private partnerships to make IP available to scientists who need it. It accelerates the discovery and development of technologies for NTDs, malaria and tuberculosis by sharing IP on a royalty-free basis with the global health research community, catalysing and fostering global health collaborations, and contributing to capacity-building in developing countries. WIPO Re:Search's 149 members spread across 42 countries on six continents include eight of the world's leading pharmaceutical companies – Eisai, GlaxoSmithKline, Johnson & Johnson, Merck, MSD, Novartis, Pfizer, & Takeda -- as well as prestigious academic institutions and research institutes from the public and private spheres. Over the past decade, WIPO Re:Search has fostered among its members 164 collaboration agreements, of which 52 are currently active and 11 are advancing through key milestones on the product development pathway. Source: World Intellectual Property Organization

3. *Health Emergencies, Infectious Disease Outbreaks, and the COVID-19 Pandemic*

STI are key enablers in the response to the health, economic, and social disruptions caused by infectious diseases and the COVID-19 pandemic. This section will focus on the contribution of STI to infectious disease responses in diagnostics, early warning and disease monitoring, and contact tracing.

<u>Diagnostics</u>

An important application of STI in infectious diseases and the COVID-19 pandemic is the development and delivery of diagnostics and testing. An important challenge in the COVID-19 pandemic is managing testing capacities to ensure fast reaction to possible critical development. As an example the Vienna BioCenter, the University of Vienna and the Medical University Vienna are engaged in a joint venture, the Max Perutz Labs, a research and training center where around 500 scientists work on fundamental research in the field of molecular biology. In the wake of the current COVID-crisis, the Max Perutz Labs in cooperation with other Austrian universities are conducting the "Vienna COVID-19 Diagnostics Initiative (VCDI)". The initiative aims to better understand the role of schools in the COVID-19 pandemic and to provide data for judging the effectiveness of measures implemented at schools to prevent the spread of the virus. Using a new gargle method, the local testing capacities will have been increased significantly. Based on a successful pilot study, a large-scale sentinel surveillance system is now implemented at Austrian schools for the school year 2020/2021. In

[19] https://hbr-org.cdn.ampproject.org/c/s/hbr.org/amp/2019/12/how-one-person-can-change-the-conscience-of-an-organization

total, approximately 14,000 pupils and 1,200 teachers from 250 schools will be invited to participate in the study and will be tested during the school year. [20]

For testing, the widespread access to community testing and self-testing with automation and acceleration of reporting to public-health databases can offer a great advantage over traditional testing.[21] The symptom-based case identification through the use of AI-powered CT imaging interpretation tools can improve diagnostic accuracy, ultimately making diagnostics more effective and available to larger numbers of people by reducing CT reading time.[22] Korona Onlem, as a machine learning-based COVID-19 pre-evaluation application, enables individuals to evaluate themselves for potential COVID-19 infection ratio through a couple of detailed questions. Following the completion of questions, the application displays the possible Covid-19 infection status and advises the user to visit a healthcare institution if the risk is high.[23] Moreover, AI-based heat cameras assisted in detecting the symptoms of infection with the Coronavirus. Thermal cameras monitor a rise in the body temperature to more than 37 degrees Celsius, after which people are directed to conduct more health tests or encourage them to go to home isolation in an effort to contain the spread of the Corona virus.[24]

More generally, the Ultramicroanalytic System (SUMA) has allowed the massive screening of various infectious diseases in the general population and specific groups in Cuba, such as pregnant women, blood donors, carriers of the immunodeficiency virus infection human (HIV). SUMA has contributed significantly to the control of the transmission of HIV, hepatitis B and C, dengue, and Chagas and Hansen's diseases (leprosy).[25]

Early Warning and Disease Monitoring

Early warning and disease surveillance have also seen recent developments in the available STI tools. In addition to case identification by online symptom reporting, data aggregation system for online information sources, which use natural language processing and machine learning to process and filter online data, have been developed to provide epidemiological insight and are increasingly being integrated into the formal surveillance landscape and have had a role in COVID-19 surveillance.[26] These STI tools build on earlier and continuing surveillance efforts for (zoonotic) infectious diseases (see Box 3).

Box 3: Global Early Warning and Response System for Major Animal Diseases

A zoonosis is any disease or infection that is naturally transmissible from vertebrate animals to humans. Animals thus play an essential role in maintaining zoonotic infections. Zoonoses may be bacterial, viral or parasitic, or they may involve unconventional agents. In addition to Rift Valley fever and Japanese encephalitis, other zoonotic diseases that have recently been the subject of increased public and media attention include anthrax, bovine spongiform encephalopathy (also known as mad cow disease), Crimean-Congo haemorrhagic fever, highly pathogenic avian influenza and the Ebola virus disease.

[20] Contribution from the Government of Austria
[21] https://www.nature.com/articles/s41591-020-1011-4
[22] https://www.who.int/china/news/feature-stories/detail/covid-19-and-digital-health-what-can-digital-health-offer-for-covid-19
[23] Contribution from the Government of Turkey
[24] Contribution from ESCWA
[25] Contribution from the Government of Cuba.
[26] https://www.nature.com/articles/s41591-020-1011-4

Since July 2006, outbreaks of major animal diseases have been monitored worldwide by the Global Early Warning and Response System for Major Animal Diseases, including Zoonoses, a joint system that builds on the added value of combining and coordinating the alert and disease intelligence mechanisms of FAO, WHO and the World Organization for Animal Health, for the international community and stakeholders to assist in prediction, prevention and control of threats of animal disease, including zoonoses, through the sharing of information, epidemiological analysis and joint risk assessment. Early warning is based on the concept that dealing with a disease epidemic in its early stages is easier and more economical than having to deal with it once it is widespread. Satellite-derived information on climatic factors is combined with economic indicators and migration statistics and is further integrated in epidemiological analysis for predicting disease threats. From a public health perspective, early warning of outbreaks with a known zoonotic potential will facilitate the development of control measures and the formulation of relevant preventive policies.

Source: UNOOSA

Disease epidemics often emerge as a result of natural hazards: floods increase the risk of diarrhoeal diseases and other illnesses such as malaria, cholera and dengue. The health aspects of disaster risk are dealt more in terms of the epidemics response than addressing the root causes of the risks and associated vulnerabilities A shift is called for in responding to these emergencies from being event-based to risk-based. The COVID-19 pandemic has changed the nature and scale of risk. The intersection of the COVID-19 pandemic with the disaster is an example of the cascading risk. Managing this requires data intensive impact-based forecasting and risk-informed early warning systems. To enable this, it's important to construct innovative multiple-hazard risk scenarios and associated risk matrices, including around the best approaches to risk governance in the face of cascading risk, strengthened preparedness and multi-sectoral coordination[27] (see *Box 4*).

Space science and technology provide important tools that can support public health stakeholders in planning, research, prevention, early warning, alerts, and health-care delivery. Information derived from Earth observation and meteorological satellites in combination with geographic information and global navigation satellite technologies has increasingly been used to study disease epidemiology, enabling increased use of spatial analysis to identify the ecological, environmental, climatic and other factors that can have a negative effect on public health or can contribute to the spread of certain diseases. United Nations entities assist developing countries in making use of space-based solutions to fight the spread of these diseases.

In the area of health protection, space technology is well suited to the dynamic nature of outbreaks and epidemics of infectious diseases. Tele-epidemiology is employed by United Nations entities in cooperation with a diverse community of partners to provide information and develop models to support outbreak awareness, preparedness, response and control strategies. Tele-epidemiology combines the use of information from satellite-based platforms to investigate and forecast outbreaks and the re-emergence of infectious diseases. The use of remote sensing has significantly advanced the possibility to track and visualize the real-time evolution of local outbreaks and epidemics and map the environmental influences for the

[27] Pathways for managing cascading risks : ESACP (https://www.unescap.org/resources/pathways-manage-cascading-risks-and-protect-people-south-asia-key-takeaways-stakeholders)

epidemics and critical public health infrastructure. Space-derived information is used in tele-epidemiology in programmes for specific diseases, such as yellow fever, cholera, and leptospirosis, to develop a decision-support tool and to provide information for current vaccination strategies.

Box 4 : Managing the cascades of COVID-19 pandemic and extreme climate events

The ESCAP's Asia-Pacific Disaster Resilience Network (APDRN)[1], a Network of the Networks, is configured as regional component of the WMO's led International Network for Multi-Hazard Early Warning Systems (IN-MHEWS). The APDRN was activated to provide risk analytics solutions for managing the cascading risks – intersection of COVID-19 with extreme climate events.

Predictive risk analytics: In South Asia, the most immediate concern was the monsoon season of June to September 2020 when spread of the COVID-19 was rapidly growing. The APDRN translated seasonal outlook of South West monsoon to impact forecasting to visualize the potential impacts of cascading risks[1]. The cascading risk hotspots were indicated for taking preparedness measures and policy interventions to reduce the impacts of floods and drought while managing the risks of COCID-19 transmission simultaneously [1]. The climate related disasters have different risk pathways from COVID-19, but they can intersect and converge with the pandemic in complex and destructive ways. Many communities are exposed to both, and the long-term consequences can be similar – damage to people's health and livelihoods and their prospects of escaping poverty. The predictive analytics helps to manage the cascading risks scenarios.

Descriptive risk analytics: The new demands of COVID-19 during disaster responses were evident in May 2020 during cyclone Amphan which hit densely populated low-lying coastal areas of Odisha, West Bengal in India, and adjoining Bangladesh. The large-scale evacuations in the path of the cyclone were relied on precise early-warning systems that saved thousands of lives[1]. Unavoidably these measures also increased the risk of infection. In India it was reported that 59 members of the National Disaster Response Force and 170 personnel who fought against cyclone Amphan tested COVID-19-positive. There were similar issues in June when cyclone Nisarga struck densely populated areas on the west coast of India – where COVID-19 was already spreading fast. Here again, precise early warning followed by large-scale evacuations undoubtedly saved lives. However, COVID-19 infections accelerated: between May and June 2020 the number of confirmed cases in India rose from 100,000 to 440,000. There is no scientific evidence that disaster-related disruptions in social distancing increased the number of infections, but they will certainly have played a part. For such complexities, scenario based and data intensive risk analytics that enable impact-based and risk-informed early warning systems can play an important role in saving lives and reducing transmission of the diseases[1].

Source: ESCAP

Earth observation data and field data are being increasingly integrated into disease models to map and predict changes in habitats and biodiversity and calculate risks to public health. Land-use dynamics, animal reservoir mapping, the state of forest cover and water reservoirs are key determinants for the plague, Lyme disease and other vector-borne diseases. The models help environmental decision makers and public health practitioners to better understand the effectiveness of intervention measures, such as repellents, integrated pest management, land-use practices and disease treatment.s

Data dashboards are increasingly being used, collating real-time public-health data such as confirmed cases, deaths and testing figures, to keep the public informed and support policymakers in finetuning their policies. [28] For example, in Russia an online information resource (COVID-19) was created to monitor the dynamics of morbidity, mortality, the provision of medical personnel (including labor incentives), specialized beds, and to identify the need for them. The mechanism includes predictive techniques and allows quick response to the situation. When creating sthis mechanism, modern methods of information protection and personal data protection were used. The Ministry of Health of Russia, together with the expert community, promptly developed temporary Methodological Recommendations "Prevention, diagnosis and treatment of a new coronavirus infection (COVID-19)".[29]

Another activity which focused on issuing health certificates is the COVID-19 Credentials Initiative (CCI)15, which aims to support projects developing and deploying verifiable credential solutions to help stop the spread of COVID-19 in a controlled, measurable, and privacy-preserving way.[30] Using industry standards, like the Verifiable Credentials by World Wide Web Consortium (W3C), CCI works on architecture guidance that all participants could use to solve COVID-19 credential use- cases, such as a digital certificate that prove a negative test result.[31]

Contact Tracing

The COVID-19 pandemic has been accompanied by the emergence of digital contact-tracing apps that enable contact tracing on a scale and speed not easily replicable without digital tools (see Box 5).[32] Emerging research using simulation models show that contact tracing paired with case isolation has the potential to control a new COVID-19 outbreak within 3 months.[33] A model developed in the UK predicts that effective contact tracing could reduce the number of untraced infections to less than 1 in 6 cases.[34] However, most studies on contact tracing for COVID-19 are modeling or observational studies, and the evidence at this point is low to definitively assess its effectiveness in the future of the pandemic.[35] Furthermore, reticence by some populations to not adopt these contact tracing tools and the community spread of infectious diseases can inhibit its potential effectiveness.

[28] https://www.nature.com/articles/s41591-020-1011-4
[29] Contribution from the Russian Federation. For more information, see: https://static0.minzdrav.gov.ru/system/attachments/attaches/000/052/219/original/%D0%92%D1%80%D0%B5%D0%BC%D0%B5%D0%BD%D0%BD%D1%8B%D0%B5_%D0%9C%D0%A0_COVID-19_%28v.8.1%29.pdf?1601561462.
[30] The idea of Covid credentials has also been controversial because of its potential to create biases and discrimination, and public health risk (e.g., it creates a negative incentive to become infected in the hope that a "certificate of immunity" would facilitate employment later).
[31] Contribution from UNECE. CCI, "The COVID-19 Credentials Initiative website, 2020, is available at https://www.covidcreds.com.
[32] https://www.nature.com/articles/s41591-020-1011-4.
[33] https://www.sciencedirect.com/science/article/pii/S2214109X20300747
[34] https://jech.bmj.com/content/74/10/861
[35] https://www.medrxiv.org/content/10.1101/2020.07.23.20160234v2

With the Hayat Eve Sığar (Life Fits Into the House) applsication, individuals are informed with periodical messages on Covid-19 and motivated through displaying the exact status of the infection all around the country. As a part of that operation, people can track their family etc. upon the open consent of the tracked and psychologically and socially supportive contents are shared with individuals. As part of the system, users can generate HES codes for sharing Covid-19 risk status with institutions and individuals for activities like transportation or visit. Shared HES codes can be checked through the app or services provided to institutions. This code solely serves as a risk mitigator for infection in long distance transportation vehicles during travel. Covid-19 patients or contacted people will not be able to use public transportation. This code is utilized by the Ministry to inform people if anyone in the same vehicle is diagnosed as positive.[36]

Although contact tracing in combination with large-scale testing and isolation can reduce the spread of COVID-19, this technology also presents challenges for data protection.[37] Some COVID-19 tracing apps, like Singapore's TraceTogether or Europe's Pan-European Privacy-Preserving Proximity Tracing, use a "privacy by design" approach that notify potentially exposed individuals while preserving privacy. At the end of May 2020, a voluntary tracing app "Apturi COVID" ("Stop COVID" in English) was launched in Latvia. It uses Bluetooth technology to identify other nearby devices that also have the app installed. Individuals are only notified if they have been in the proximity of 2 meters to an individual for more than 15 minutes who has tested positive for COVID-19. They receive a message asking them to self-isolate to prevent the further spread of the disease. Due to the decentralized and encrypted nature of the app, it aligns with European Union regulations on data protection. The availability of the newly released exposure notification API by Google and Apple is a fundamental building block to ensure widespread use of the app.[38]

Box 5: Examples of Digital Applications to Combat COVID-19 in Latin America

Colombia: "SegCovid19" is a web application that records the health monitoring of people living in Colombia in the COVID-19 pandemic. The web application allows the recording of information on the health status of people with confirmed diagnosis, discarded or possible cases of COVID-19, with or without risk factors, who are residents of Colombia and the monitoring of home or hospital isolation.

Mexico: Innovation for the pandemic has also included the use of big data and predictive models to help authorities make better decisions on certain measures. An important example of this is in Mexico, specifically in Mexico City. The National Agency of Public Innovation (Agencia Digital de Innovación Pública (ADIP)) developed a compartmentalised epidemiological model[39] based on deterministic differential equations, based on a SEIR (Susceptible, Exposed, Infected and Recovered) model with additional adjustments was used to model both hospitalizations without ventilation and intubations. This model was intended as an additional input to assist in decision-making by the Mexico City Mayor's Office and the members of the Metropolitan Health Committee, in order to strengthen the response to the SARS-CoV-2 pandemic, which caused the COVID-19 disease.[40]

[36] Contribution from the Government of Turkey
[37] https://www.healthaffairs.org/do/10.1377/hblog20200515.190582/full/
[38] Contribution from the Government of Latvia
[39] MODELO EPIDEMIOLÓGICO COVID-19 DEL GOBIERNO DE LA CIUDAD DE MÉXICO, https://modelo.covid19.cdmx.gob.mx/modelo-epidemico
[40] Contribution from ECLAC

Argentina: As an integral part of the public health care and prevention strategies in the face of the Covid-19 pandemic, the national government developed the “Cuidar” application. The application Cuidar - Covid 19 enables self-diagnosis of symptoms, provides assistance and recommendations in the case of compatibility with coronavirus and provides tools for contacting those cases to health authorities. The application is linked to a broader system that articulates the information that the application collects with the health areas responsible for emergency care, both national and provincial governments.[41]

Source: ECLAC

Climate-induced public health threats

According to the fifth assessment report of the Intergovernmental Panel on Climate Change, climate change is affecting health both directly, as a result of changes in temperature and precipitation and the occurrence of heatwaves, floods, droughts and fires, and indirectly, as a result of ecological disruptions brought on by climate change, such as crop failures and shifting patterns of disease vectors, or social responses to climate change, such as the displacement of populations following prolonged drought. Space-based technologies can thus contribute to the assessment of the direct effects of climate and weather on health, as well as ecosystem-mediated effects of climate change on health outcomes. Space-based technologies can also be used to support operational work in the public health sector, such as mapping of the geographical distribution of meteorological events posing risks to public health and critical public health infrastructure.

For example, the Vulnerability and Risk Analysis and Mapping programme of WHO uses remotely sensed and other environmental information and combines it with disaggregated vulnerability and capacity indicators to identify population and health services at risk of hazards such as floods, droughts and heatwaves and to enhance efforts to reduce disaster risk. Kenya’s Meteorological Service in Weather Early Warning in Kenya entails provision of timely and effective weather information that allows individuals, organisations, or communities exposed to likely weather hazards to take action that avoids or reduces their exposure to risks.[42] Such technologies also have a potential to map other climate-related issues such as heatwaves and help discriminate between the effects of sudden extreme weather events and longer-term and slow-onset climate effects.

II. Frontier technologies for healthcare

In many cases, simple and well-established solutions can be used to address primary healthcare, maternal and child health, neglected diseases of the poor and infectious diseases. However, other aspects of healthcare development and delivery may require new and emerging technologies. In this section, frontier technologies like digital health, gene-editing, space application, blockchain and other technologies are discussed with respect to their potential for addressing health issues and the achievement of SDG3.

1. *AI, Data and Digital Health*

[41] Contribution from ECLAC
[42] Contribution from the Government of Kenya

Data and digital health are catalysts for accelerating achievement and monitoring progress on SDG3. The increased use of telemedicine, contact tracing, wearable health sensors, and AI in medicine is reshaping health systems and response to health emergencies. From managing the population's health more effectively to improving the diagnosis of diseases and monitoring the impact of health-related policies and interventions, data and digital technologies for health, or digital health, are bringing profound changes to how health services are delivered and how health systems are managed.[43]

E-health is a generic term used to refer to all digital health-related information and online care delivery. Telemedicine and teleconsultations, electronic health records and hospital and health information systems, e-prescriptions and computer-assisted imaging are examples of modalities in e-health. In its resolution 58.28, the World Health Assembly stressed that e-health was "the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research". Tele-health and telemedicine applications embrace computer and telecommunications technologies, including satellite communications, to bring medical experts into virtual contact with patients or doctors in remote and rural areas, thus avoiding costly relocation to hospitals in urban areas, which could prove detrimental to the patients' health.[44]

It is predicted that the healthcare landscape will completely shift in the next 10 years, driven by AI and machine learning (AI/ML). By aggregating and analysing data from connected-home devices and medical records, healthcare systems will be able to deliver proactive and predictive medical care, provided issues about privacy, regulatory compliance and connectivity are addressed. Responsibly unlocking the potential of data in health: As technology becomes more integrated in health services, there is and will continue to be, a huge increase in both the generation and usage of health data. Telemedicine, health chatbots/ apps, and smart watches coupled with monitoring of social media and web data is bringing an opportunity to leverage this generated data to better understand and yield insights about health.[45] 5G technologies, the next generation of mobile internet connectivity that offer higher speed, lower latency and higher capacity for communication, could support many of these applications of digital technologies to healthcare through quickly transmitting large amount of data, expanding telemedicine and reliable, real-time remote monitoring.[46][47]

Digital Solutions for Primary Health Care

Primary health care, which is at the heart of SDG 3, is where data and digital health can make significant contributions by improving the ability to gather, analyze, manage and exchange data and information. For instance, data and digital health have been used for 1) electronic health records that allow the sharing of information about an individual's health for referrals and timely clinical decision-making; 2) telemedicine, remote care and mobile health including the home monitoring of vital signs and medication adjustments which reduce paperwork and cost for healthcare providers, improve safety in management of medication for elderly or other vulnerable groups; 3) the application of big data and artificial intelligence to enable complex

[43] https://www.who.int/docs/default-source/primary-health-care-conference/digital-technologies.pdf?sfvrsn=3efc47e0_2(accessed
[44] Contribution from UNOOSA
[45] Contribution from ESCWA
[46] UNCTAD. "Technology and Innovation Report." Geneva: UNCTAD, (forthcoming).
[47] https://www.business.att.com/learn/updates/how-5g-will-transform-the-healthcare-industry.html#:~:text=With%205G%20technology%2C%20which%20has,their%20patients%20need%20and%20expect.

clinical decision-making and the identification and reporting of adverse events; and 4) developing medical and assistive devices and services such as 3D printing that has revolutionized the manufacture of devices and equipment.[48] WHO considers that an educated, aware and engaged public is a goal of primary health care and in this regard, digital health can support active engagement of the population for their health and well-being, for example by connecting to high-quality health information and patient communities online.[49]

There are indeed more than 120 countries that have national policies for digital health, recognizing the fact that digital health provides opportunities to accelerate the progress towards SDG 3.[50] For example, the strategy for the development of healthcare in the Russian Federation for the period up to 2025, approved by the Decree of the President of the Russian Federation of June 6, 2019 No. 254, includes the tasks of creating a single digital circuit in healthcare based on a single state information system in the healthcare sector. This digital circuit suggests a creation of centralized digital platforms in order to diagnose diseases, including with the use of artificial intelligence, the development of personalized medicine based on modern scientific achievements, the development and introduction of modern molecular genetic methods of forecasting, current diagnosis and monitoring of diseases, methods of personalized pharmacotherapy, including genetic editing technologies and targeted therapy.[51] The Kenyan Government's "Big Four Agenda" has health specifically attaining Universal Health Coverage by 2022. To ensure universal health is attained, the country is looking at a number of e-services to meet the needs of a population with limited spending power and poor access to formal health care facilities given the large penetration of mobile in the country.[52] Latvia's Digital Transformation Guidelines 2021-2027 (under development) provide for development of data exchange between research institutions, as well as for development of telemedicine.[53]

Challenges to harness data and digital health

On the other hand, there are unique challenges in the use of data and digital health to accelerate progress on SDG 3. Developing the digital skills of the health workforce is critical and there need to be health professional training and education programmes, while also the digital literacy of users (patients) should be improved. Despite the potential of telemedicine, most countries do not have a regulatory framework for telemedicine that enables its authorization, integration and reimbursement. The COVID-19 pandemic could be a catalyzing factor for countries to develop the regulatory frameworks that could scale the adoption of telemedicine.[54]

Unfortunately, the digital divide persists, hindering the potential adoption of digital health. Although mobile networks reach 95% of the global population, global internet access only

[48] https://www.who.int/docs/default-source/primary-health-care-conference/digital-technologies.pdf?sfvrsn=3efc47e0_2(accessed
[49] https://www.who.int/docs/default-source/primary-health-care-conference/digital-technologies.pdf?sfvrsn=3efc47e0_2(accessed
[50] https://www.who.int/health-topics/digital-health#tab=tab_1
[51] Contribution from the Russian Federation
[52] Contribution from the Government of Kenya. Example of digital health initiatives are: (1) Mobile money transport vouchers for mothers to get free transport to give birth to their child in health centres; and (2) Changamka Micro Health, which through its product "Linda Jamii" allows Kenyans to access health insurance by using savings from their mobile money (M-Pesa) accounts.
[53] Contribution from the Government of Latvia
[54] https://publichealth.jmir.org/2020/2/e18810/?utm_source=TrendMD&utm_medium=cpc&utm_campaign=JMIR_TrendMD_0

stood at 53% in 2019.[55] LDCs and developing countries lag their developed country counterparts while Africa, Arab States and Asia & Pacific have less internet access than the Americas and Europe. Even when broadband connectivity is available in developing countries, its productivity benefits for business are limited because it tends to be relatively slow and expensive. Digital infrastructure investment is critical to addressing the inequalities in internet access and leveraging the benefits of digital health, particularly in the least developed countries, landlocked countries and small island developing States where low population densities, geographical constraints, and limited resources make it more difficult for private investors to secure rapid returns on capital.[56]

For developing countries to effectively harness ICTs for health systems (in general or as part of health emergency response) requires the building of digital competencies and an enabling environment. Digital competencies can be strengthened by education policy that accommodates digital skills' training schemes in formal education curricula, as part of the on-the-job training, and in the context of lifelong learning. The creation of an enabling environment can make access to ICT-enabled health innovations possible through the following policies and institutional development, including: investments in ICT infrastructure; big data analysis and decision-making capabilities; open government data tools; incentives encouraging investment and labor market participation in the digital economy; and ICT foresight capacities.[57]

Highly granular or personal data for public-health purposes raises security and privacy concerns. Also, the security and privacy of freely available communication platforms used for digital health purposes remains a concern, particularly for the flow of confidential, highly private healthcare information.[58] To address the issue of privacy in contact tracing during pandemics, for example, several international frameworks with different degrees of privacy preservation are emerging, including Decentralized Privacy-Preserving Proximity Tracing, the Pan-European Privacy-Preserving Proximity Tracing initiative and the joint Google–Apple framework but the issue of privacy and security remains a large concern in harnessing data and digital health.[59]

Safety is one of the biggest challenges for AI in healthcare. In one well-publicized example, IBM Watson for Oncology uses AI algorithms to assess information from patients' medical records and help physicians explore cancer treatment options for their patients. However, it has recently come under criticism by reportedly giving "unsafe and incorrect" recommendations for cancer treatments. The problem seems to be in the training of Watson for Oncology. Instead of using real patient data, the software was only trained with a few "synthetic" cancer cases devised by doctors at the Memorial Sloan Kettering (MSK) Cancer Center. MSK has stated that errors only occurred as part of the system testing and thus no incorrect treatment recommendation has been given to a real patient

AI has the capability to improve healthcare not only in high-income settings, but to democratize expertise and deploy it to remote areas. However, any machine learning (ML) system or human-trained algorithm will only be as trustworthy, effective, and fair as the data that it is trained with. AI also bears a risk for biases and thus discrimination. It is therefore vital that AI

[55] UNCTAD. "Fifteen Years since the World Summit on the Information Society." Geneva: UNCTAD, 2020. https://unctad.org/en/PublicationsLibrary/dtlstict2020d1_en.pdf.
[56] UNCTAD. "Building digital competencies to benefit from frontier technologies" Geneva: UNCTAD, 2019. https://digitallibrary.un.org/record/3813136/files/UNCTAD20193.pdf
[57] https://unctad.org/en/PublicationsLibrary/dtlstict2019d3_en.pdf
[58] https://www.nature.com/articles/s41591-020-1011-4
[59] https://www.nature.com/articles/s41591-020-1011-4

makers are aware of this risk and minimize potential biases at every stage in the process of product development. In particular, they should consider the risk for biases when deciding (1) which ML technologies/procedures they want to use to train the algorithms and (2) what datasets (including considering their quality and diversity) they want to use for the programming.

Lastly, because some digital health solutions particularly the ones that utilize big data and artificial intelligence are only as good as the data they use as inputs, the trust and quality of the health data is of great importance. For instance, public-health organizations and technology companies have been trying to mitigate the spread of misinformation and disinformation, and to prioritize trusted news sites; for example, Google's SOS alert intervention prioritizes the WHO and other trusted sources at the top of search results.[60] Equally, governments should ensure transparency in their datasets, including epidemiological data and risk factors, making them easily accessible to researchers.[61] Also, the evidence of the effectiveness of digital health solutions, although particularly difficult during pandemics due to the time constraints, needs to be peer-reviewed and undergo thorough clinical evaluation for further improvement and lessons learned (see Box 6).[62]

Box 6: Benchmarking Framework for AI in Health

The ITU-WHO Focus Group on Artificial Intelligence for Health (FG-AI4H) is a joint initiative of ITU and WHO that is driven by member states, private-sector ITU members, academia and other IOs such as PAHO. FG-AI4H is creating a benchmarking framework to assess the accuracy of AI in health diagnostic aids, such as apps that can give a risk assessment of e.g. skin lesions, or x-ray images.[63] The benchmarking framework will ensure that any potential biases are detected. In response to the COVID-19 emergency, its ad hoc group on digital health for the COVID-19 health emergency has collected best practices covering the use of AI and other digital technologies for the entire epidemic emergency cycle. The FG-AI4H also has an activity for collecting and developing relevant open source tools.

Source: ITU

2. *Space applications for health*[64]

Space applications provide innovative tools to improve lives and accelerate sustainable development in many areas, and health is one of them. UNOOSA helps all countries access the potential of space science and applications and integrate these tools in national policies and practices. We present some examples of how space can help us achieve better health worldwide, and of what UNOOSA is doing to contribute to this goal, from increasing international knowledge sharing to providing ad-hoc training and resources.

Such approaches include the use of space science and technology for health promotion, health protection, surveillance, health-care delivery in remote areas using telemedicine and tele-health services. Space science and technology provide innovative research platforms for advancing

[60] https://www.nature.com/articles/s41591-020-1011-4
[61] https://www.nature.com/articles/s41591-020-1011-4
[62] https://www.nature.com/articles/s41591-020-1011-4
[63] The framework is detailed in a commentary in the *Lancet*: https://doi.org/10.1016/S0140-6736%2819%2930762-7. More information can be found on the website: https://www.itu.int/go/fgai4h/.
[64] Based on contribution from UNOOSA

medical knowledge and spin-offs for the development of health-care equipment, operational activities, and procedures. Space-based data and technologies foster connectivity in health emergencies, and the integration of space-derived information in health-care systems supports the mapping of populations, the treatment of diseases, the distribution of medication, transportation systems and water supply and sanitation and facilitates the monitoring of trends in air quality and health-related environmental factors.

Satellite communications are essential for tele-health and for the management of epidemics in cases involving natural or human-made disasters. Early warning and disaster preparedness rely on data collected by satellites and validated by fieldwork. Such data products, when incorporated in a geographical database, could be used to develop spatial models for predicting high-risk areas. Space stations and their Earth-bound analogues serve as platforms for health studies. Efforts are also being made to promote international cooperation in the peaceful uses of outer space for economic, social and scientific development, in particular for the benefit of developing countries. Priorities include building indigenous capability in space policy, science and technology in the area of global health.

Exposure to particulate air pollution — and the burden of disease — can be estimated using surface monitoring stations. The urban air pollution exposure database of the WHO Global Health Observatory already includes such data on over 1,500 cities throughout the world. However, many parts of the developing world, including urban and rural areas, are not included. As a result, scientists have been working to devise methods to combine surface monitoring data with data from satellite remote sensing and atmospheric transport models. To advance the use of air pollution disease burden estimates, WHO has begun the development of a global platform on air quality and health, building on its existing urban air pollution database, as well as available satellite remote sensing and atmospheric transport model data from leading national and scientific institutions throughout the world. Augmenting ground-based measurements and model estimates with remote-sensing data makes it possible to increase the availability of global information on key air pollutants, especially for the most highly polluted and data-poor regions.

Inadequate water, sanitation and hygiene continue to pose a major threat to human health. Water quality is continuously monitored to control water characteristics, identify trends over time, identify emerging problems, determine whether pollution control programmes are working, help design pollution control efforts and respond to emergencies such as floods and spills. Traditional monitoring of water quality involves on-site sampling of water and subsequent laboratorial analyses. While this provides accurate measurements, it is normally costly, time-consuming, and indicative only of the situation at the particular points where the samples were obtained. Wider coverage of water quality observations can be obtained by satellite-based remote-sensing technology, which is suitable for near-real-time geographical coverage of water quality of inland freshwater systems, such as lakes, reservoirs, rivers and dams, and which is capable of detecting lake eutrophication, light penetration, phytoplankton bloom, chlorophyll levels, turbidity and other parameters.

Lakes, rivers and seas are used for a variety of recreational activities, including swimming, diving, fishing and sailing. If these activities are to be enjoyed safely, attention must be given to health hazards such as water pollution or excessive growth of toxic cyanobacteria. Space technology, through its Earth observation applications, provides vital information for assessments and monitoring programmes for bodies of water used for recreation.

3. *Blockchain for Health Emergencies*

The COVID-19 pandemic has caused unprecedented changes and disturbances in the economic, health and social fields, both at individual and societal levels. At the same time, it provided context for frontier technologies to address the pressing challenges. In like manner, the COVID-19 pandemic has paved the way for "blockchain" technologies to prove its usefulness in improving the transparency between integrated networks. Such links between data platforms and systems organized shipment of medicines to areas suffering from an outbreak of the virus, contributes to the continuation of the economy, facilitates the management of cash flow for emerging companies, guarantees payment of installments for their products and helps consumers to track Movement of their requests until it reaches them.[65]

Blockchain technology can be used to manage COVID-19 certification for passengers passing through airports and other public facilities. ESCWA (in collaboration with International Chamber of Commerce, OakPass, and IATA, Emirates Airlines, and others) have piloted an initiative to provide technology-based certifications of PCR certificates passing through international borders.[66] Similarly, the Covid19 Pass project on the HashNET platform has the goal to create the C-19 Pass digital certificate (to be issued by health authorities)) that shows the holder has tested negative for the virus and allows the holder to commute and visit designated venues (C19CNV) Certificates are uploaded to HashNET DLT and are retrieved by the holder's smartphone app as a reference QR code that can be scanned at C19CNV venues.[67]

The current COVID-19 situation has a disruptive impact on global supply chains, with the closure of international borders, diminishing of goods or parts transportation and distribution limitations, among others, affecting the availability of emergency medical supplies or equipment, or increasing the food demand. Within this context, UNIDO will explore the use of blockchain for improving the efficiency, transparency, traceability, and security of crucial supply chains in the short, medium, and long term. The Global Quality and Standards Programme (GQSP) will support the development of national systems for verified and traceable competences of medical analysis and testing laboratories using blockchain technology, allowing in times of crisis rapid verification of competences and reliability of test capacity. Moreover, the use of blockchain-based smart contracts will be piloted to automate processes, reduce costs and integrate different actors involved at the different levels of sourcing, procurement, manufacturing, distribution, and logistics; to promote more transparent and resilient supply chains.[68]

4. *Other applications of frontier technologies for health*

Other advanced technologies to realise SDG 3 include the Internet of Things (IoT), remote control and autonomous vehicles, such as drones, robotic process automation (RPA), 3-D printing, geolocation services, and remote monitoring. These technologies have been leveraged to facilitate international trade by utilizing global digital platforms, digital products, legally recognized digital credentials and new (non-contact) delivery methods. They help realize contactless transactions, safe, resilient, secure and efficient transactions.[69] These technologies are beneficial for SDG3 because they create a disruption-resilient supply chains, international trade and logistics by benefiting from the dematerialization of business processes, documents and assets, making trade of essential items and services more efficient, secured and always on-

[65] Contribution from ESCWA
[66] Contribution from ESCWA
[67] Contribution from UNECE. Tolar.io, "HashNET Distributed Ledger Technology (DLT), 2020, available at: https://tolar.io/hashnet.
[68] Contribution from UNIDO
[69] Contribution from UNECE

going. These technologies also enable "contact-free" transactions in between persons, reducing risks of potential contaminations (see Box 7). [70]

Box 7: Autonomous vehicles, robots, and drones minimizing infection during health emergencies

In a partnership between UNIDO's ITPO in Shanghai and the Beijing-based White Rhino Auto company, unmanned vehicles were set to work at Wuhan's Guanggu Field Hospital. The JD.com e-commerce company began road-testing the country's first domestically developed self-driving delivery vehicle in September 2016, and several other companies quickly joined in a race to seize the market. However, with the outbreak of the coronavirus in Wuhan in Hubei province in December 2019, a new role for the unmanned delivery vehicle soon emerged. Two White Rhino vehicles were brought to Wuhan from Beijing by the company to transport medical supplies, deliver meals for doctors and patients, and complete other emergency tasks in the hospital. The use of the unmanned vehicles not only helped avoid cross-infection but also reduced the workload of the hard-pressed medical staff.[71] Robots have provided an around-the-clock alternative to human force in high-risk situations especially during the initial breakout of the virus when little was known about the disease. Thus, robot solutions were scrutinized by decision makers as a viable answer to address the constrictions put forward by the COVID-19 lockdown and high infection rates. In addition to self-driving vehicles and robots, autonomous drones have been used to deliver medical supplies and vaccines in remote areas. In Rwanda, the government partnered with a robotics company, Zipline, to address maternal mortality by using drones to deliver blood to medical facilities, reducing the time to procure blood from four hours to fifteen minutes.[72] Vanuatu embarked on a world-first trial in 2018 to deliver temperature-sensitive vaccines to remote villages via commercial drones.[73] Sources: UNIDO, ESCWA, and UNECE

Nanotechnology has provided enormous opportunities and solutions in the areas of prevention (e.g. masks and disinfectants), detection (e.g. nano-sensors) and treatment (e.g. nano-medicines) to combat the current COVID-19 pandemic as well as future probable deceases. Nanotechnology is shaping the medical practice by providing small and simple imaging instruments, "labs on a chip" in point of care diagnostics and water disinfection with nanotechnology. In this regard, the development and practical application of advanced technologies like nanotechnology to address healthcare needs close cooperation among government and institutions worldwide.[74]

III. Strengthening national capacities for health innovation

[70] Contribution from UNECE
[71] https://www.unido.org/stories/stopping-spread-covid-19-disinfecting-public-spaces-china
[72] Rozen WJ (2017). Zipline's Ambitious Medical Drone Delivery in Africa. MIT Technology Review. June 8, 2017. Available at https://www.technologyreview.com/s/608034/blood-from-the-sky-ziplines-ambitious-medical-drone-delivery-in-africa/.
[73] https://www.unicef.org/press-releases/child-given-worlds-first-drone-delivered-vaccine-vanuatu-unicef
[74] Contribution from ESCAP

Science, technology, and innovation's potential role in extending health and well-being to all is shaped by health innovation systems, inclusive policy frameworks, and multisectoral partnerships across and outside of government. The longer-term process of building effective innovation systems can help developing countries effectively utilize existing, new and frontier technologies in their pandemic recovery and accelerated actions to achieve SDG 3 on health and well-being.

1. *General challenges in healthcare innovation ecosystems in developing countries*

UNCTAD STI policy reviews in Ethiopia, Ghana, and Iran have looked at issues highly relevant to the health system in developing countries, providing results that can inform the issue of improving health through STI. Common challenges relate to deficiencies in R&D skills, STEM skills more broadly, the R&D infrastructure, R&D investment by both the public sector and the private sector, and the testing and quality systems. Technology development is a common challenge, especially with the commercialization of research that is undertaken. Accessing technology is also frequently a challenge, with relatively low rates of access to modern machinery and equipment that have embedded technologies.

The challenges go beyond purely technical knowledge and skills, which are in the form of skilled people and equipment with embedded technology, and the infrastructure and investment related to creating and using technical knowledge. Many challenges concern converting knowledge and skills into local innovations that are useful for health. These challenges originate from diverse parts of the innovation systems in developing countries. They include deficiencies of funding, physical infrastructure deficiencies (power, transport, clean water and ICTs), weak linkages between research and industry, weak private sectors with mostly small firms that face constraints that larger firms can overcome, challenges in commercializing research, challenges with awareness of intellectual property and using the intellectual property system, issues with assessing and accessing markets, and weaknesses related to defining and enforcing regulatory frameworks, standards, testing and quality systems..[75]

Policy action - planning, design and implementation of policies - is required to strengthen innovation systems for health, medicines and other medical products. Challenges with policy planning include weaknesses in policy design processes (often related to insufficient cross-ministry and private sector collaboration), inadequate policy implementation and poor or non-existent monitoring and evaluation practices.

Internet access is a key infrastructure for digital health, but it requires reliable electricity access. Affordable, accessible, and reliable electricity plays an important role in economic structural transformation of developing countries[76] and the potential adoption of health-related technologies. The number of people without access to electricity was 770 million in 2019, with 75% of the unconnected population living in sub-Saharan Africa, a share that has risen over recent years.[77] Considering the COVID-19 pandemic, it is essential that health and hospital facilities in low and middle income countries have reliable and secure access to electricity[78] and that cold storage infrastructure is available for vaccine delivery, esp. in rural and remote areas. Relevant work by international organizations include vaccine cold chain infrastructure

[75] Access to financing, technological obsolescence and the preservation of human capital are common barriers to healthcare innovation. Source: Contribution from the Government of Cuba.
[76] UNCTAD (2017). The Least Developed Countries Report 2017: Transformational Energy Access. United Nations: Geneva and New York.
[77] IEA (2020) "SDG7: Data and Projections. Access to affordable, reliable, sustainable and modern energy for all" https://www.iea.org/reports/sdg7-data-and-projections
[78] https://www.uneca.org/stories/renewable-energy-investments-crucial-africa%E2%80%99s-efforts-build-back-better-post-covid-19

by GAVI[79], reports on modern energy services to health in resource-constrained settings[80], and specific UN programs on solar for health.[81]

In addition to the infrastructural constraints, technological capacity gaps between developed and developing countries limit the potential adoption of health technologiess. Average R&D intensity in 2017[82] in North America and Western Europe (2.5%) and East Asia and the Pacific (2.1%) exceed the world average of 1.7%. On the other hand, Central and Eastern Europe (1.0%), Latin America and the Caribbean (0.7%), Arab States (0.6%), South and West Asia (0.6%), Sub-Saharan Africa (0.4%), and Central Asia (0.2%) fall below the global average.[83] The density of researchers is also unevenly distributed around the world. The number of researchers per million inhabitants sits at a global average of 1198 (in 2017), with Europe and North America (3707) and Eastern and South-Eastern Asia (1468) exceeding the world average. Other regions lag the world average, including Northern Africa and Western Asia (854), Latin America and the Caribbean (515), Central and Southern Asia (287), and Sub-Saharan Africa (99).[84]

2. *Building the science and talent base for healthcare innovation*

Substantial investments in STI infrastructure, institutions and human capital – all the underpinnings of sound innovation systems must be an integral part not only of the immediate response to the COVID-19 crisis and persistent health challenges but also of the long-term effort to ensure that all countries can quickly rebuild better and prepare for similar future challenges.[85] Even if the need for stronger innovation systems in developing countries is accentuated by the COVID-19 crisis this is a long-standing development bottleneck; it is critical that investments are made and policy support to STI provided with a long-term perspective and a commitment to continuity (see Box 8).

There is evidence that government expenditures to encourage R&D are far more effective when they are stable over time.[86, 87] Firms hesitate to invest in additional R&D if they are uncertain of the durability of government support. Predictability and long-term perspectives in funding are also critical for research undertaken by academic institutions. Similarly, investment in

[79] Franzel, L. and A. Brooks (2016) The system is the innovation: how to support countries to enhance and expand vaccine delivery systems, pages 206-2015 in Bound, K. and Ramalingam, B. Innovation for International Development: Navigating the Paths and Pitfalls https://www.nesta.org.uk/report/innovation-for-international-development/.

[80] Access to modern energy services for health facilities in resource-constrained settings: a review of status, significance, challenges and measurement: https://apps.who.int/iris/bitstream/handle/10665/156847/9789241507646_eng.pdf

[81] UNDP's Solar for Health Programme: https://stories.undp.org/solar-for-health

[82] Expenditure on R&D as a proportion of GDP, also known as R&D intensity, is the most widely used indicator of countries' efforts on STI. R&D comprises creative and systematic work undertaken to increase the stock of knowledge, including the knowledge of humankind, culture and society, and to devise new applications of available knowledge (OECD, 2015). It covers three types of activity: basic research, applied research and experimental development.

[83] UNESCO. 2020. "Global Investments in R&D" Fact Sheet No. 59, June 2020, FS/2020/SCI/59. URL: http://uis.unesco.org/sites/default/files/documents/fs59-global-investments-rd-2020-en.pdf

[84] UNESCO. "News: UIS Data for SDG 9.5 on Research and Development (R&D)" Source: http://uis.unesco.org/en/news/new-uis-data-sdg-9-5-research-and-development-rd

[85] UNCTAD. "The Need to Protect Science, Technology and Innovation Funding During and After the COVID-19 Crisis." Policy Brief, May 2020. https://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=2735.

[86] Guellec D and Potterie B van P de la (2000). The Impact of Public R&D Expenditure on Business R&D

[87] Mitchell J et al (2019). Tax incentives for R&D: supporting innovative scale-ups? Research Evaluation, 29(2):121–134

human capital can suffer from stop-and-go policies. Faced with unstable academic research systems and uncertain career prospects promising researchers are likely to switch to other career paths or migrate to countries where STI investments are stable or continue to grow.

In several countries, health accounts for a significant proportion of R&D and S&T budgets. In Cuba, 26% of all institutions dedicated to science are in charge of research, development and innovation for health and belong to the Ministry of Public Health (MINSAP), the Group of Biotechnology and Pharmaceutical Industries (BioCubaFarma), universities and other sectors. MINSAP decides the priorities of the sector in harmony with the guidelines of the country's economic and social policy.[88] In 2016, the budget allocated by the State to science and technology in the health sector accounted for 35.4% of the total allocated to science and technology in Cuba.[89] Similarly, in Ecuador, the country invested 11.74% in the health area as a proportion of I&D investment in 2014. The government body in charge of STI, in the period 2005-2018, invested 12% in medical science (USD $ 21,868,722).[90]

Efforts to strengthen the STI resources of developing countries could distinguish between the needs of the immediate response and the longer-term strategies. During the crisis, support to research and development should be included in emergency measures and recovery fiscal packages. R&D grants, particularly to work on issues such as therapeutics or measures to prevent the spread of disease and that are adapted to the specific needs and environment of developing countries, or to support knowledge-intensive firms (particularly smaller ones) that may have been particularly hit by the crisis, are good candidates. Smart recovery packages also present an opportunity to prioritize investments in innovation-enabling infrastructure, particularly for the digital economy, to support the transition to renewable energy and more efficient and environment friendly manufacturing and services (for example transport and logistics). [91]

In the longer term a "forward guidance" approach (committing to a growth path of future government R&D expenditures) can be an effective tool. Already some regional organizations have set targets for R&D expenditure as percentage of GDP such as the European Union's 3 per cent target and the African Union's 1 per cent target. Likewise, developing countries could revisit and set their targets and, importantly, establish their spending trajectory towards them. This way, governments can not only treat R&D expenditures as "protected funding lines" but also ensure and signal the continuity and predictability of government R&D support to other stakeholders.[92]

Box 8: Building innovation capacity for local pharmaceutical production in Ethiopia

Ethiopia's health sector strategy's main goal is to ensure that everyone who needs health services can get them without undue hardship. The STI policy review of Ethiopia of 2019 looked at the role of STI in the pharmaceuticals industry. The Ethiopian case illustrates the need for alignment of STI policy along with health and industrial policies to build health security by improving the ability of the country to address the national health needs of their population.

[88] Contribution from the Government of Cuba.
[89] Contribution from the Government of Cuba.
[90] Contribution from the Government of Ecuador
[91] UNCTAD. "The Need to Protect Science, Technology and Innovation Funding During and After the COVID-19 Crisis." Policy Brief, May 2020. https://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=2735.
[92] UNCTAD. "The Need to Protect Science, Technology and Innovation Funding During and After the COVID-19 Crisis." Policy Brief, May 2020. https://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=2735.

However, many challenges still must be faced to achieve rapid improvement and impact in improving national health outcomes. A range of deficiencies in the pharma innovation system that impede local health innovation must be overcome. Both R&D capacity and production capacity are gradually improving but require further strengthening and at a more rapid pace than is currently happening. On the policy side, achieving a high level of implementation of the policies has proved a challenge. Capacity constraints at research and industrial institutes, a bioequivalence centre, and the universities, in terms of R&D infrastructure, R&D financing, skills and budgets undermine progress. The research performance of Ethiopia in health has improved, but weak R&D capacity and deficiencies in funding for R&D persist in both the public education and research systems and in industry. The skills base is improving but is not yet adequate. Research-industry linkages are also generally weak.

Most pharma firms operating locally face a mix of basic technological capabilities, low R&D capacity and operating with less productive technologies in the form of outdated machinery and equipment. Many producers have not yet upgraded adequately to meet good manufacturing practices (GMP). They face major challenges in the business environment such as shortages of foreign exchange, lack access to credit for investment in expansion and upgrading, and deficiencies in physical infrastructure such as unreliable power supply, weak transport systems and lack of clean water supply. The technical skills base remains insufficient, and shortages in skills result from high rates of turnover of technically proficient staff who move across the industry and into other non-pharma related activities in search of higher salaries. Regulatory capacity continues to be strengthened. Challenges also remain in the quality infrastructure, particularly with the testing and maintenance of equipment. There is also a high level of dependence on imports for active pharmaceutical ingredients, which are not produced locally. As a result, the local pharma industry remains small, and currently fills only 15% of local market needs for essential medicines, leaving most high-priority medicines undersupplied.

A main lesson is that the challenges for improving health security involve more narrow science, R&D, and technology aspects as well as broader issues in the pharma and health innovation systems. The entry of foreign generic producers and the establishment of joint ventures with local firms as a means of technology transfer and building innovation capacity may help to accelerate local pharma production capacity and strengthen health security in the future. The STIP review made recommendations to address these different challenges.

Source: UNCTAD (2020) Science, Technology & Innovation Policy Review of Ethiopia. Geneva: United Nations. UNCTAD/DTL/STICT/2020/3. Available at: https://unctad.org/system/files/official-document/dtlstict2020d3_en.pdf

3. *Commercializing R&D into healthcare products and services*

Even when the science and talent base for healthcare innovation is in place, many countries can face challenges translating this innovative capacity into products and services that benefit patients in the national healthcare system and in regional or global markets (see Box 9). According to R&D surveys conducted in Turkey, the health sector has the lowest likelihood of commercialization with a ratio of 3%. R&D and innovation in the health sector tend to comprise longer terms and periods, such as clinical stages in comparison with any other R&D intensive sector. R&D and innovation processes, especially in the sub-fields of pharmaceuticals, vaccines, biomaterials, and treatment development, take at least a time duration of 10-15 years, besides the higher costs.[93]

Box 9: Iran's efforts to translate research capacity into biotechnology innovation

The STI policy review of Iran of 2016 looked at the development of biotechnology for health. The country has sought to build national capacity to manage its health risks and meet domestic health needs. Iran has a relatively strong national capacity to produce essential drugs and medical equipment to meet national health needs, built by decades of investment in science, technology, engineering and mathematics (STEM) skills, research capacity and health infrastructure and technological infrastructure as goals of five year national development plans going back over two decades. Biotechnology policies have focused mainly on the development of human capital and research capabilities, basic prerequisites for building strong biotech innovation capacity.

The country established ambitious targets for biotech and biopharma development, and national plans with various support measures since 1990 to establish supporting institutions, build infrastructure, skills and research and production capacity. Education and skills development have progressed well, along with published research in biotech. Production capacity for generic and biosimilar drugs is relatively strong. Iran now produces biological materials for use in R&D, generics and biosimilar drugs, and medical equipment to meet local needs. Local pharma producers meet the bulk of local market needs (97% in 2016). However, growing strength in human capital and research publications has not been fully matched by an improved innovation performance, judged by the number of international patents, the commercialization of research and the relatively small number of domestic firms that had developed strong original innovation capacity in health biotech by the time of the review. In contrast, strong basic innovation capacity had been built across the country in the health and biotech innovation systems.

Several challenges in the biotech innovation system have undermined original innovation capacity. These relate more to non-technical challenges rather than STEM skills and lack of R&D capacity, which are bigger challenges in less technically proficient countries. These include inadequate access to finance for risky and long-term biotech R&D, the lack of intense competition in the country to force firms to innovate, persisting weaknesses in the national systems of certification and testing, inadequate research-industry linkages and marked limitations in international collaboration and access to international markets and international funding due to international sanctions.

The STIP review made recommendations to address the major challenges, including: (i) improve financing for biotechnology; (ii) enhance collaboration between biotech knowledge-based firms and mature firms; (iii) strengthen international collaboration and access to the international market; (iv) develop efficient technology transfer offices in universities and research and technology organizations to accelerate the process of commercialization; (v) improve the accreditation system by enhancing laboratory and testing equipment and facilities; (vi) enhance local content policies as well as public procurement in favor of innovations in biotechnology; and (vii) strengthen applications of the four main sub-sectors of biotechnology.

[93] Contribution from the Government of Turkey

Source: UNCTAD (2016) Science, Technology & Innovation Policy Review of the Islamic Republic of Iran. New York and Geneva: United Nations. UNCTAD/DTL/STICT/2016/3. Available at: https://unctad.org/system/files/official-document/dtlstict20163_en.pdf.

Some countries have support programs that target productive and collaborative interactions between R&D and innovation actors in the local ecosystem. In this respect, the focus of some policy efforts is to proactively enable a "closing of the innovation gap" between R&D and innovation actors as areas of important opportunities.[94] Through the newly established program launched by TUBITAK for strengthening collaborative R&D linkages within the local ecosystem named "the Industrial Innovation Networks Mechanism (SAYEM)" private sector firms, especially those that possess an R&D and product design centre, form a network with other firms of the value chain of the targeted technology-based product, together with end-users, technology development zones and universities. The network is to be provided the opportunity to take center stage in the innovation system for co-creating high value-added products and technologies for the market.[95] Thailand's Medical Hub Policy focuses on four major areas (wellness, medical services, academic and medical centre, and health products) with a view to link these areas with its "Thailand 4.0" policy and stimulate economic development on the Eastern Economic Corridor. The government also promotes technical assistance and R&D grants to help with the establishment of bioscience companies.[96]

Another area of interest for some countries is the local production of essential medicines. UNIDO has supported developing and least developed countries in this area by increasing access to high-quality essential medicines and vaccines through, for example, helping to address the scourge of substandard and falsified medicines. The issue of local pharmaceutical production, particularly in Africa, has attracted significant interest during the COVID19 crisis due to the potential to address the security of supply challenges given the reliance on imports from distant geographies. Enhancing local production of essential medicines to improve access to high-quality products requires a multifaceted approach enabling improved quality and commercial viability of existing manufacturers and new entrants to the market. It requires initiatives covering access to investment and technology, capacity building for industry stakeholders, market transparency and opportunities for international standard products. UNIDO has been active at the global, regional, and national level supporting the design and implementation of strategic initiatives to help drive transformation on this long-term agenda.[97]

4. *Promoting a whole-of-government and multi-sectoral approach*

To be effective, STI policies need to be internally consistent and aligned with national health priorities and development plans. The former can be promoted through the design and deployment of strategies and policy instruments at the most appropriate level, while the latter requires a "whole-of-government" perspective, facilitating cooperation across ministries and other public bodies in different fields of policy. Coherence is needed between STI policies and policy areas such as industrial policies, trade, foreign direct investment (as knowledge and

[94] Contribution from the Government of Turkey
[95] Contribution from the Government of Turkey
[96] Contribution from the Government of Thailand
[97] Contribution from UNIDO

technology are often being transferred through trade and foreign direct investment), education and competition.[98]

In some developing countries, responses to the COVID-19 pandemic involve multi-sectoral and multi-disciplinary actors within and across government. For example, since December 2019, Zambia National COVID-19 Research and Innovation Plan was jointly spearheaded by the Ministry of Science and Technology and the Ministry of Health. [99] Thailand's Center for COVID-19 Situation Administration (CCSA), which was setup by the Prime Minister, included the National Research Council of Thailand and the Ministry of Higher Education, Science and Innovation.[100] Such collaborative efforts across government can build a foundation for STI policies that move beyond a focus on economic competitiveness or science funding towards sustainable development and integrating health and societal challenges to their cores.[101]

Some countries have established effective cross-ministerial collaboration on healthcare-related sectors. For example, to a large degree policy coherence has been achieved in Ethiopia with respect to pharma production. There has been a relatively good level of collaboration across key ministries, departments and agencies, particularly between the Ministry of Health and the Ministry of Trade and Industry - that characterizes a "whole of government" approach. This has been promoted through a collaborative structure established under a pharma sector strategy in place to support local pharma production.[102] Cuba's health innovation system is organized into 37 science and technological innovation entities: 16 research centers, 3 scientific-technological services, and 18 development and innovation units that are administratively subordinate to the Ministry of Public Health (MINSAP) and methodologically to the Ministry of Science. Technology and Environment (CITMA).[103] Portugal's Agency for Clinical Research and Biomedical Innovation (AICIB) has four partners, including the Ministry of Health and the Ministry of Science and Technology.[104]

Multi-stakeholder collaboration, in addition to a whole-of-government approach, is needed to ensure that health innovations involve the support of all key national stakeholders and are included in national action plans. In Austria, scientific research at medical universities often takes place in cooperation with non-university research partners as well as national and international partners and companies and scientific societies (e.g. Ludwig Boltzmann Institutes).[105] Multi-stakeholder partnerships can support national funding for healthcare innovation. The health sector in Kenya relies on several sources of funding: public (government), private firms, households, and donors (including NGOs) as well as health insurance schemes. Some of the Public-Private Partnerships project partners who have been

---

[98] UNCTAD. "Technology and Innovation Report 2018: Harnessing Frontier Technologies for Sustainable Development." Geneva and New York: UN Conference on Trade and Development, 2018. https://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=2110.

[99] https://unctad.org/en/Pages/CSTD/CSTD-and-COVID-19.aspx,

[100] Contribution from the Government of Thailand

[101] UNCTAD. "New innovation approaches to support the implementation of the sustainable development goals." Geneva and New York: UN Conference on Trade and Development, 2017. UNCTAD/DTL/STICT/2017/4. Available at: https://unctad.org/system/files/official-document/dtlstict2017d4_en.pdf

[102] UNCTAD Secretariat, based on Ethiopia STIP Review (2019)

[103] Contribution from the Government of Cuba.

[104] Contribution from the Government of Portugal

[105] Contribution from the Government of Austria. Examples are the Cooperation Center for Regenerative Medicine between the Medical University of Graz and Joanneum Research. Another example is the "Platform for Personalized Medicine" funded by the BMBWF, which aims to intensify national cooperation in this field and - in line with the ERA Roadmap - to provide a starting point for a wide range of international projects.

involved with the Ministry of Health include USAID, WHO, The Kenya Red Cross Society, The Global Fund and World Vision[106].

Multi-stakeholder collaboration can involve civil society and citizen scientists in addition to conventional R&D and S&T institutions. For example, Austria's medical universities have recently agreed to participate in the projects *Responsible Science and Citizen Science* in their internal training measures, in particular with regard to increased interaction with society. The spectrum ranges from the pollen warning service, the Teddy Bear Hospital to pilot projects with a Citizen Science component supported by the university as part of the start-up support for young scientists. This could also include the *Open Access Initiative* of Austrian universities with the support of the BMBWF (see also FWF).[107]

IV. Mobilizing international action in science, technology, and innovation for health

Addressing global challenges in vastly different local contexts requires the combination of cutting-edge scientific capabilities with detailed local knowledge. Global collaboration can contribute to this process, providing opportunities both to create new knowledge and to increase the impact of research by diffusing existing knowledge, quickly and at all levels.[108] With fast movements of goods and people across borders in the increasing globalization context, countries have become inter-dependent in the health sector. Regional and global action is needed to deepen research cooperation, reimagine health innovations as global public goods, and shape global norms and frameworks on emerging health and medical technologies.

1. Supporting national health innovation ecosystems

Deepening Access to Digital Health

There are many examples of international cooperation to build capacities for digital health at the national level. The UN Technology Innovation Lab or UNTIL generates scalable, SDG-based digital solutions for the needs of developing countries and the UN. UNTIL's expertise in relation to digital health should be utilized. Finland works with UNTIL as part of our contribution to the follow-up of the High-level Panel on Digital Cooperation, under the recommendation that focuses on Digital Public Goods. With Finnish funding, a project carried out by UNTIL will develop guidance for digital public goods in the area or maternal, new-born and child health.[109] Another example is the case of Healthcare Information and Management Systems Society, Inc. (HIMSS) supporting the Turkish Ministry of Health in a digitization project for the Turkish healthcare system. This hospital digitalization success is the product of strong collaboration and shared vision of public and private sectors, universities, and affiliated professional organizations together.[110]

Support by the international community – including regional and international cooperation-engaging multi-stakeholders (i.e. national governments, the private sector, research platforms for economic discovery and technical education and training institutes) will need to expand to enable the potential promise of digital health. The COVID-19 experience highlights the need

---

[106] Contribution from the Government of Kenya. Source: Evanson Kiambati Minjire (2015). Public-Private Partnerships in the Healthcare sector of Kenya
[107] Contribution from the Government of Austria
[108] UNCTAD (2020). Impact of the COVID-19 Pandemic on Trade and Development: Transitioning to a New Normal. Geneva: United Nations. UNCTAD/OSG/2020/1. Available at: https://unctad.org/system/files/official-document/osg2020d1_en.pdf.
[109] Contribution from the Government of Finland
[110] Contribution from the Government of Turkey

to build and truly invest in and scale a new digitalized infrastructure, and efforts on supporting the provision of affordable internet connection and necessary public services, such as health. Thus, there is scope for scaling up regional intergovernmental cooperation and implement policies that promote the benefits of digital healthcare.[111] Such cooperation should include ICT education and training to build digital capabilities as well as entrepreneurship training (see Box 10).

Box 10: Lessons learned from Belgian Federal Development Cooperation on Digital Technologies in Development Programmes

Below are several **lessons learned** by the Belgian federal development cooperation when making use of digital technologies in development programmes:

1) **Cooperation between public and private sector** is important. Belgium is at the basis of the European D4D-HUBEU-Africa, where cooperation between private and public sectors is paramount.
2) **Digitalization accelerates the implementation of all SDG's**. Digital technologies make for increased cost-efficiency.
3) The **digital principles** (www.digitalprinciples.org) are a set of living guidance intended to help practitioners succeed in applying digital technologies to development programs. They are central in the Belgian D4D strategy.
4) The **connectivity** debate (how to connect all regions across the world) should be based on a **cost-benefits** analysis. Innovative financial mechanisms are necessary.
5) **"Offline strategies"** i.e. measures, strategies and actions that influence the context of the project are as important as the technical components in a digital project. This refers to the human rights and freedom of speech context, but also to the fight against cyber criminality and how local politics are conducive of a favorable digital eco-system.
6) **Digital divide**; Leave no one behind. The growing gap in connectivity amongst the population often reflects the gap in access to basic social goods (electricity, water, food, etc.) Partners should not work in silo and should see connectivity as one of the "global public goods". This is best exemplified by the need for digital education in the context of COVID-19 restrictive measures.

Source: Government of Belgium

Shaping Scientific Networks and R&D for Healthcare Innovation

The global community could continue to shape scientific R&D networks for global health, including through the prioritization of health concerns for developed and least developed countries and supporting developing countries' participation in regional and global health research networks. If the international community strengthens global collaboration in scientific research and innovation, it could potentially provide new opportunities for the combination of the most advanced scientific capabilities, with detailed local knowledge in key areas of sustainable development.

A 2018 study investigated the effect of publishing in OA journals and international collaboration within and between European and sub-Saharan African countries on citation impact on poverty-related disease papers. The analysis showed that publishing research on

[111] Contribution from ESCAP

diseases such as malaria in OA and in international collaboration has a significant and meaningful citation advantage over non-OA or non-international collaborative research. Publishing papers as part of a European-wide or European- sub-Saharan African collaboration increases research impact. In contrast, such collaboration advantage is not observed for research output involving sub-Saharan Africa only which seems to decrease research impact.[112]

European research programs often support national research infrastructures.[113] For example, the EU Horizon 2020 projects have supported Turkish universities on a wide range of topics in health (e.g., diagnostics, vaccines, cancer, biomedical devices, etc). Between 2015 and 2020, Turkish Universities have participated in 27 Horizon 2020 health projects with a total project budget of 461 Million Euros.[114] The International Consortium for Personalised Medicine (ICPerMed) aims at providing a flexible framework for cooperation between its member organisations to work on fostering and coordinating research as a driver for personalised medicine implementation.[115]

Governments are well poised to influence international research networks, which require an understanding of their formation, organization, norms, dynamics, motivations, and internal control mechanisms. Healthcare innovation and targeted interventions for the COVID-19 pandemic can be enhanced by mapping existing scientific knowledge and current research against local needs, to target research and avoid redundancy, and using gap analysis to develop sufficient absorptive capacity to retain knowledge locally.[116]

One of the most favourable arrangements that has gathered momentum during the COVID-19 pandemic is the open science approach which enables the free use of what would otherwise be proprietary information, which scientific collaboration is increasingly relying upon. Open science refers to efforts by researchers, governments, research funding agencies or the scientific community itself to make the primary outputs of publicly funded research results – publications and the research data – publicly accessible in digital format with no or minimal restriction as a means for accelerating research; these efforts are in the interest of enhancing transparency and collaboration, and fostering innovation.[117] Similarly, open access (OA) means **free access to information** and **unrestricted use of electronic resources** for everyone. Any kind of digital content can be OA, from texts and data to software, audio, video, and multi-media.[118] The International Vaccine Institute is a partner in three consortia funded by Fleming Fund Regional Grants to strengthen the capacities of local, national, and regional health systems in LMICs to track the spread of antimicrobial resistance (AMR) and to share AMR data using a One Health approach.[119] Open platforms in healthcare innovation are a potentially promising avenue of scientific and innovative collaboration (see Box 11).

---

[112] Breugelmans JG, Roberge G, Tippett C, Durning M, Struck DB, MakangaMM (2018) 'Scientific impact increases when researchers publish in open access and international collaboration: A bibliometric analysis on poverty-related disease papers.' *PLoS ONE* 13(9): e0203156. https://doi.org/10.1371/journal.pone.0203156
[113] Contributions from the Governments of Portugal, Romania, and Turkey.
[114] Contribution from the Government of Turkey
[115] Contribution from the Government of Portugal
[116] UNCTAD Technology and Innovation Report 2018
[117] OECD (2015), "Making Open Science a Reality", *OECD Science, Technology and Industry Policy Papers*, No. 25, OECD Publishing, Paris: http://dx.doi.org/10.1787/5jrs2f963zs1-en
[118] UNESCO, 'What is open access?' Available at: https://en.unesco.org/open-access/what-open-access
[119] Contribution from International Vaccine Institute

Box 11: openIMIS for Social Health Protection Schemes in Developing Countries

openIMIS is the first open source software that supports the management of social (health) protection schemes. It links beneficiary, provider, and payer data. It is a powerful tool to strengthen strategic purchasing of health services and digital processing of health system data. With support from the Swiss Agency for Development Cooperation (SDC) in 2012, an IMIS was developed to operate community health funds in several districts of Tanzania. In 2014, a mutual health insurance scheme in Cameroon adapted the software. Since 2015, the German Development Cooperation (GDC) has been providing assistance to customize IMIS for Nepal's national health insurance scheme. The software has grown organically and has demonstrated potential for easy adaptation to different types of health financing mechanisms needed for UHC. In 2016, GDC and SDC invested jointly to make IMIS an open source application. The openIMIS source code is publicly available since 2018. SDC and BMZ are launching a catalytic fund in 2020 to allow new countries and initiatives to adapt and use the software.

openIMIS has a front-end interface that allows for quick registration procedures even in remote rural areas and can be used online and offline. The modules can be customized to specific country and organizational needs. openIMIS is interoperable and is designed to help to solve the data fragmentation puzzle. It interfaces with other IT tools in the health and social protection sector to connect data sources and users. openIMIS uses international standard protocols and codes (e.g. diagnosis codes) and requires services from multiple standard health sector applications (DHIS2, medical records) and beyond (e.g. civil registries).

Source: Government of Switzerland

Building healthcare innovation capacities

Bilateral and multilateral cooperation and technical cooperation projects from international agencies can support the building of national capacities for healthcare innovation. The Federal government of Belgium and the Flemish authorities financially support the Institute for Tropical Medicine Antwerp, which has numerous cooperation with health institutes and health authorities in developing countries. Whereas digital technologies are often used in those cooperation projects (for exchange of knowledge, training, etc.), scientific innovation and research as well as capacity building are the main drivers for this type of cooperation. For instance, the Department Foreign Affairs of the Flemish authorities supports cooperation between the Institute for Tropical Medicine Antwerp and the "Instituto Nacional de Saúde" in Maputo, Mozambique. The partner organization is a reference testing facility and laboratory of the Ministry of Health in Mozambique. As such, it played a key-role in Mozambique's COVID-response.[120]

Portugal maintains several collaborations in health with many Portuguese speaking countries. In one example, Portugal has capacitated Mozambique in epidemiological surveillance. In a second example, Portugal and Guiné-Bissau had a great cooperation project for a twinning laboratory in the National Institute of Health from Guiné. This twinning laboratory initiative was first established for Ebola and then further extended to other infectious diseases. In a third example, Portugal has cooperated directly with Angola's Ministry of Health for the development of the health system and the definition of health policies. Other cooperative areas

[120] Contribution from the Government of Belgium

with Angola covered Newborn screening, tuberculosis, health research, entomology, quality control, etc. [121]

Given the importance of experience and knowledge sharing among all countries in their fight against COVID-19, Turkey launched an e-learning project with World Health Organization to share Turkey's experience with COVID-19. The e-learning project will focus on Turkey's experience on epidemiology, diagnosis, case management, ICU management, microbiology, radiology, infection control and vaccine studies. The first round of trainings is planned for Turkic Council Member Countries, the second round for Eastern European Countries and the third round for African Countries. The project will offer training videos through a web-based portal of the Ministry to the health workforce of targeted countries. Additional modules and applications will be developed to offer training courses on USES.[122]

WIPO's Re:Search Fellowship Program helps developing countries increase their scientific and research capacity by establishing research sabbaticals, generously supported by funds-in-trust (FIT) from the Government of Australia. The program builds an international community of researchers to catalyse R&D for diseases of poverty. Through this program, pharmaceutical companies and academic research institutes with advanced laboratories host scientists from low- and middle-income countries (LMICs) to provide training and conduct mutually beneficial research collaborations. As of September 2020, WIPO Re:Search has organized 20 fellowships for researchers from LMICs, totalling 100+ months of training. Fellows cite the following as benefits of this program: quicker career development and promotions, acceptance into post-graduate programs, attainment of faculty positions, and broader recognition of research via publications. [123]

UNCTAD and Okayama University in Japan launched in 2020 the Young Female Scientist Programme with the aim of building human capital in science, technology and innovation-related fields in developing countries. The focus is particularly on young women scientists, because closing the gender gap as spelled out in SDG5 will be key to accelerate progress in harnessing science, technology and innovation for inclusive and sustainable development for all communities and all countries. The participating young female scientists will conduct the cutting-edge research in their respective fields of sciences in Japan for 2-4 weeks and bring back home their experiences to contribute to their countries' development. Most of the participating scientists have chosen health-related research, including health sciences; medicine, dentistry and pharmaceutical sciences; environmental and life science; natural science and technology; and interdisciplinary science and engineering in health systems.

Strengthening innovation in healthcare industries

Bilateral, regional, and international cooperation arrangements are potential mechanisms for the building and strengthening of innovation in healthcare industries. UNIDO's ongoing project titled "Fostering Slovenian – Cuban innovation cluster for biopharma, medical and nanotechnologies sectors 2020 – 2021" is aiming is to promote innovation and collaboration in the field of the biopharmaceutical, medi-tech and nano-tech sectors, contributing to improving the economic growth and the quality of life. The specific objective is to foster Slovenian – Cuban innovation cluster development in biopharma, medical and nanotechnologies sectors during the period 2020 – 2021. Likewise, the project aims to establish strategic alliances

[121] Contribution from the Government of Portugal
[122] Contribution from the Government of Turkey
[123] Contribution from WIPO

between Cuban and Slovenian partners for developing commercially viable and bankable business proposals in the identified priority sectors.[124]

Another example of international cooperation in the field of healthcare innovation is the links established between the BioCubaFarma Group and various Chinese entities. The creation of the Beijing-based joint venture BIOTECH PHARMACEUTICALS, was the first in China to produce monoclonal antibodies for the treatment of cancer, including Nimotuzumab (for esophageal cancer) and the Cimavax-EGF vaccine (for lung cancer).[125] The CHANGHEBER joint venture, located in the Jilin province of China, is in charge of developing and commercializing the recombinant interferon alpha 2B, Cuban patent, for the treatment of viral hepatitis, and is in the process of assimilating other technologies of Cuban biotechnological products. Joint laboratories have also been set up between the two countries, research centers and projects aimed at ailments of the central nervous system, such as dementia and Alzheimer's.[126]

At the regional level, the Conference on Science, Innovation and Information and Communications Technologies (a subsidiary body of ECLAC) approved a regional cooperation proposal, which includes measures to develop the health-care industry at the national and regional levels, as well as fostering regional R&D networks. The idea is for it to work on the development of mission-oriented industrial and technological policies, the promotion of strategic partnerships for regional integration, the creation and strengthening of a regional market through recognition of regulatory bodies and coordination of public procurement, and the creation and expansion of capabilities at the regional level.[127] In the African region, ITC is playing a role in strengthening value chains for the medical sector (see Box 12) and UNIDO is supporting the development of the pharmaceutical sector.[128]

Box 12: Regional Value Chain Development for the African Medical Sector

ITC has developed a method to identify opportunities for developing regional value chains, including in the medical sector. By using innovative word matching and text-to-data techniques, an input-output table was developed at the product level. Previous input-output tables at the sector level are not detailed enough to identify new products for export diversification based on existing inputs. The detailed production coefficients obtained allow ITC to assess whether available inputs in a country or a region could be transformed into a final product in sufficient quantities to meet demand. ITC applies this novel methodology in project design to prioritize the most promising products and sectors for trade support initiatives. It also informs their partner countries' export strategies and trade support instruments.

In cooperation with the Malawi Trade and Investment Center, ITC developed an online tool that identifies value-added products for export diversification, based on the ITC methodology (malawi.exportpotential.intracen.org). ITC recently applied this method in a report commissioned by UN DSG to evaluate how African countries could work together to develop regional value chains in health-related products. It is estimated that the ethanol required to provide 500,000 litres of disinfectants per month to the African continent

[124] Contribution from UNIDO
[125] Contribution from the Government of Cuba.
[126] Contribution from the Government of Cuba.
[127] Contribution from ECLAC
[128] Contribution from UNIDO

corresponds to 2.2% of South Africa's monthly exports.[129] Egypt could contribute lids and bottles, while the required glycerol could be sourced from international suppliers with untapped potential, such as Germany and Malaysia. Developing these regional value chains would reduce the dependency on few international suppliers of essential products and hence mitigate the impact of pandemics on the African health sector.

Source: International Trade Centre[130]

2. *Making healthcare technologies accessible for all[131]*

To address the needs of health systems in developing countries, international collaboration in scientific research can play a critical role in improving health, equity, and sustainable development. It can particularly make an important contribution in the context of diseases that are disproportionately prevalent in developing countries, but where research capacity may be limited. To enable their success, collaborative arrangements should ideally seek to foster equitable relations between the collaborating parties. This may be through formalized partnership agreements, whereby parties that contribute resources (know-how, biodiversity, finances, etc.) towards a common goal can achieve mutually beneficial outcomes, including the possibility of joint ownership of intellectual property rights (IPRs). On the other hand, collaborative arrangements may seek to issue licenses (either paid or unpaid) for the equitable use of IPRs such as inventive technologies protected by patents, innovation designs protected by design rights, research publications protected by copyright, or technical information such as clinical data and processes protected by trade secrets. Alternatively, a waiver of IPR barriers or enabling open access for scientific collaboration may be issued for the purpose of achieving specific outcomes aimed at addressing health challenges such as COVID-19. A number of approaches may be used to ensure the equitable use of IPRs for scientific collaboration.

Access to benefits and sharing (ABS)

One approach that seeks to derive mutually beneficial collaboration is the access and benefit sharing (ABS) instrument – an international regime which is defined and governed by Article 15 of the United Nations Convention on Biological Diversity (CBD)[132] for which further detailed mechanisms for its implementation was provided by the Nagoya Protocol which came into force in 2014.[133] The instrument was conceived with the aim of fostering equitable relations between those parties providing genetic resources and associated traditional knowledge and those wishing to make use of them for scientific research or R&D in the development of commercial products for the purpose of human welfare, such as pharmaceuticals. For developing countries, granting access to genetic resources in exchange

---

129 WHO estimate

130 Additional Sources: Medical Industries in Africa: A Regional Response to Supply Shortages, ITC Technical Paper 2020, https://www.intracen.org/publication/Medical-Industries-in-Africa/. Blog: Strengthening African value chains in medical supplies, https://www.intracen.org/covid19/Blog/Strengthening-African-value-chains-in-medical-supplies/.

131 Important dimension of making healthcare technologies accessible for all is the need for financing the last mile in scaling innovations and public-private partnerships. Contribution from WHO.

132 Article 15 – Access to Genetic Resources, Convention on Biological Diversity (CBD): https://www.cbd.int/convention/articles/?a=cbd-15

133 Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization to the Convention on Biological Diversity: https://www.cbd.int/abs/doc/protocol/nagoya-protocol-en.pdf

for a share of monetary and non-monetary benefits could have positive impacts for sustainable development. In terms of the non-monetary benefits, this could be particularly useful for facilitating the transfer of technology and know-how to address, for instance, neglected diseases – for which developing countries account for much of the related biodiversity source.

ABS links access to genetic resources and traditional knowledge to the sharing of monetary and non-monetary benefits, which may include joint ownership of intellectual property rights (IPR). Several IPR models have been adopted in ABS agreements but most commonly companies have sole ownership of IP. For example, in the partnership between Diversa Corporation, the Kenya Wildlife Service (KWS) and the International Centre of Insect Physiology and Ecology (ICIPE) in Kenya, the company retains intellectual property rights over any products that it develops, provided that ICIPE and KWS have the option of a royalty free license that allows them to research, develop and otherwise make use of any products or inventions developed from the material supplied within the jurisdiction of the Republic of Kenya (but not beyond this jurisdiction).[134]

However, various challenges and shortcomings surrounding the ABS approach has surfaced in recent years, including the fact that both commercial and non-commercial research requires substantial investments of time, money, and capacity to receive permits or sign ABS agreements in countries with unclear legal and administrative structures. Parties wishing to share in the intellectual property from a successful development must be prepared to make a significant financial investment to share the risk of failure, but such investments are often beyond the reach of many providing institutions.[135] One possibility to offset this obstacle is through the provision of public funding from national and international agencies to be directed towards efforts in creating an enabling environment for scientific research in developing countries. This could provide a financial backstop through research grants and subsidies for international scientific partnerships. The lack of both institutional capacity and an adequate system of intellectual property rights protection in developing countries are also hurdles. This is particularly problematic, given that IPRs generally tend to be given prominence as a mechanism for benefit-sharing in ABS agreements, over and above the frequently more concrete gains of building domestic scientific and technological capacity.[136]

Another issue is the fact that, while ABS has provided an international policy dialogue on ethics and equity in research, ownership, and control of genetic resources and traditional knowledge, capacity building, technology transfer, and other issues; their governance on issues relating to equity in broader science and technology issues are limited due to the fact that they are addressed in the UN deliberations taking place under the auspices of an environmental treaty, the CBD. As a result, only parties to this conference make decisions about scientific research practices that can have impacts far afield from biodiversity.[137]

---

[134] Secretariat of the Convention on Biological Diversity (2008). 'Access and Benefit-Sharing in Practice: Trends in Partnerships Across Sectors'. Montreal, Technical Series No. 38, 140 pages.

[135] Weiss, C. and Eisner, T. (1998) Partnerships for value-added through bioprospecting. *Technology in Society*, 20: 481-498.

[136] CBD (2008).

[137] Sarah Laird, Rachel Wynberg, Michelle Rourke, Fran Humphries, Manuel Ruiz Muller and Charles Lawson, 'Rethinking the expansion of access and benefits sharing', *Science* **367** (6483), 1200-1202.

Patent Pools

A patent pool is an agreement between two or more patent holders to aggregate or pool their respective technologies and license them as a single package, either by the group of owners or by a separate entity specifically created for that purpose.[138] Patent pools can create a freedom to operate (FTO) environment for relevant technologies consolidated in one package, giving pool members and licensees the opportunity to utilize the collection of technologies included in the pool, both to bring new products to market, thereby facilitating competition in the market-place and to carry out further research and development, in order to facilitate innovation. Patent pooling is much more likely to be of relevance when multiple overlapping (and often complementary) patents operate in the same space. In the instance where patent applications are filed in the same field by a number of organizations, as was the case with the genomic sequence of the severe acute respiratory syndrome (SARS) coronavirus, this is likely to result in a fragmentation of IP rights which in turn may adversely affect the development of products such as vaccines to combat the disease.[139] Consolidating these patents into a patent pool to be licensed on a non-exclusive basis may circumvent these problems, and thereby leading to public health benefits. In the case of COVID-19, this could potentially be a useful mechanism, given the fact that many players are involved in the development of vaccines and treatments leading to multiple patent applications. Various international organizations and non-profits – such as the World Health Organization and the Medicines Patent Pool, have recently established some sort of patent pooling mechanism to facilitate access to COVID-19 IP, knowledge, and data.

However, there is a risk that patent pools could be both anti-competitive (i.e. if they encourage collusion and shield weak patents), and anti-innovative (i.e. if they do not include all necessary patents or are poorly managed and inadequately resourced).[140] It is also important to highlight the structural and legal complexities surrounding patent pools, as became evident during the SARS outbreak in the early 2000s. Researchers had initially agreed to pool their patents to help find vaccines and treatments against SARS, but the negotiations over details took so long that that the outbreak was contained before the patent pool was ever formalized.

IPR pledges

Similarly, voluntary pledges to make intellectual property broadly available to address urgent public health crises can overcome administrative and legal hurdles faced by more elaborate legal arrangements such as patent pools and achieve greater acceptance than governmental compulsory licensing.[141] COVID-19 has prompted both governments and IPR holders around the world to seek ways to increase the availability of IPR necessary to combat the pandemic. These pledges and the licenses that are associated with them are irrevocable once granted and

[138] Anatole Krattiger and Stanley Kowalski, 'Facilitating Assembly of and Access to Intellectual Property: Focus on Patent Pools and a Review of Other Mechanisms', in Anatole Krattiger et al . (eds.), Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practice (2008).

[139] Simon et al. (2005), 'Managing severe acute respiratory syndrome (SARS) intellectual property rights: the possible role of patent pooling', Bulletin of the World Health Organization 2005, 83:701-710.

[140] Dianne Nicol and Jane Nielson, 'Opening the damn: patent pools, innovation and access to essential medicines', in Thomas Pogge et al. (eds), Incentives for Global Public Health: Patent Law and Access to Essential Medicines (2010).

[141] 'Pledging intellectual property for COVID-19', *Nature Biotechnology*, Vol 38, October 2020, 1146-1150.

legally enforceable under precedents that have been recognized in jurisdictions around the world.[142]

IPR pledges can take various forms, including unilaterally through a single entity, or through a coordinated effort through a consortium of organizations that commit to the same basic terms. Medtronic (ventilators) and AbbVie (therapeutics) are examples of single organizations pledging patents for specific products related to the fight against COVID-19. It is also important to highlight that many pledges relating to patented technologies are narrow in in terms of the product range, scope of use and duration. For example, they may be limited to the most basic ventilators for the duration of the COVID-19 pandemic and a short period thereafter.

3. *Strengthening Multilateral cooperation*

The UN and the international community have a role in shaping global norms and frameworks on health innovations. It is important that the international community have a better understanding of the risk-reward tradeoffs of AI in medicine, gene editing, and other new and emerging health innovations and continue discussions on appropriate normative frameworks to guide their development and use.

ICTs in health may lead to several risks with implications for the resilience of our social, cultural and political institutions. For example, "info-demics" – or the overabundance of possibly inaccurate health information online – can make it difficult for societies to have access to trustworthy and reliable guidance on the pandemic.[143] In this context, it is important that the international community be guided by norms, ethical principles and values that direct the development and application of ICTs and rapid technological change in ways that uphold core United Nations values and principles, including human rights and advance sustainable development.[144]

Regional cooperation can advance progress on certain dimensions of healthcare innovation. For example, the *Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030)* drafted by member States of ESCAP in 2018, with much foresight, included epidemics in the Plan. It specifically requested ESCAP and its member States to strengthen regional cooperation to 1) leverage data sharing, and promote big data analytics for the containment of present and future spreads of diseases and epidemics, 2) to develop capacity on mapping health risk hotspots using geospatial information and big data, and 3) to pay special attention to the countries that are most vulnerable to emergency health situations.[145]

In 2018, the Committee on the Peaceful Uses of Outer Space (COPUOS) agreed to introduce a new item on space and global health in the agenda of the Scientific and Technical Subcommittee (STSC), and also agreed to establish a Working Group under that agenda item. UNOOSA serves as Secretariat to this intergovernmental platform. The Working Group on Space and Global Health is gathering information from States members and international organizations about their use of space applications for global health to develop concrete recommendations. It will aim to establish a platform to enhance the sharing of information, best practices, tools, and capacity-building resources in the area of space and global health.[146]

---

142 Contreras, J. L. & Jacob, M. (eds.). Patent Pledges: Global Perspectives On Patent Law's Private Ordering Frontier (Edward Elgar Publishing, 2017).
143 https://iris.paho.org/bitstream/handle/10665.2/52052/Factsheet-infodemic_eng.pdf?sequence=14
144 https://unctad.org/meetings/en/SessionalDocuments/ecn162019d2_en.pdf
145 Contribution from ESCAP
146 Contribution from UNOOSA. Comprehensive information and documentation of the Working Group are available at: https://www.unoosa.org/oosa/en/ourwork/copuos/stsc/gh/index.html.

Finally, the Commission on Science and Technology for Development (CSTD) is the focal point within the United Nations for science, technology and innovation (STI) for development. As a forum for strategic planning, sharing lessons learned and best practices, the Commission has been soliciting contributions from CSTD member states to share national and regional experiences of using science, technology, and innovation to address the COVID-19 pandemic. Through a spirit of multilateralism, Member States can continue to utilize the CSTD platform explore ways of strengthening the science-policy interface at the national and global levels and better coordinate STI-focused international cooperation.