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Middle East and North African Health Informatics Association (MENAHIA): Technological initiatives for 'One Health'

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Summary

MENAHIA (Middle East and North African Health Informatics Association) is the International Medical Informatics Association chapter dedicated to the Middle East and North Africa region. This region is rapidly growing in terms of the use of health informatics or what has been recently coined "digital health". Human health is highly affected by the health of the environment, animal health, food, nutrition, climate change, and many other factors that are beyond the biological or genetic structure of human beings. The impact of animal health and the health of the environment on people's health is an old phenomenon but recent reemerging and appearance of diseases have clearly demonstrated the link between these. The Novel Coronavirus disease (COVID-19) that almost all of us have been suffering from is an example of this.

A number of countries in the region have already shown the depth and the work that they do to integrate the concept of 'One Health' in the public health surveillance system as they have described the work that has been done to capture data from databases other than those dealing with human beings. The examples that were provided to monitor the health of animals, agriculture, environmental health, climate change, and man-made and natural disasters are just examples of what countries have been registering in their databases and informing the health authorities of these changes and emerging trends.

Keywords

'One Health'; 'One Health' informatics; Digital Health; Health Informatics; Zoonitic Diseases; Climate Change; Middle East and North Africa; MENAHIA; International Medical Informatics Association (IMIA); Algeria; Egypt; Iran; Jordan; Kuwait; Morocco; Pakistan; Palestine; Qatar; Saudi Arabia; United Arab Emirates; Health Information Technologies; Artificial Intelligence.

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1 Introduction

This year's focus of the contribution to the IMIA Yearbook of Medical Informatics is on 'One Health', which has been the central piece for discussion and presentation in this year's IMIA regional contribution. It is a philosophy that recognizes the close connection between human and animal health and the health of our shared environment. 'One Health' surveillance describes the systematic collection, validation, analysis, interpretation of data and dissemination of information collected on humans, animals, and the environment to inform decisions for more effective, evidence- and system-based health interventions" [1].

Changes in ecosystems and environmental conditions can create new opportunities for disease transmission to animals and humans. It's an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes that the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent. While health, food, water, energy, and environment are all wider topics with sector-specific concerns, the collaboration across sectors and disciplines contributes to protecting health, addressing health challenges (e.g., the emergence of infectious diseases, antimicrobial resistance, and food safety), and promoting the health and integrity of our ecosystems. By linking humans, animals, and the environment, 'One Health' can help to address the full spectrum of disease control – from prevention to detection, preparedness, response, and management – and contribute to global health security. The approach can be applied at the community, subnational, national, regional, and global levels, and relies on shared and effective governance, communication, collaboration, and coordination. Having the 'One Health' approach in place makes it easier for people to better understand the co-benefits, risks, trade-offs, and opportunities to advance equitable and holistic solutions [2].

It is estimated that zoonotic diseases cause approximately one billion cases of illness and millions of deaths worldwide each year. Zoonotic diseases account for over 60% of newly reported infectious diseases worldwide. In the last three decades, more than 30 new human infections have been discovered, 75% of which are of animal origin, including Rabies, Ebola, Anthrax, and SARS [3].

2 Technological Initiatives for 'One Health' in Countries of MENAHIA

2.1 Algeria

In Algeria, only 3.6% of the land is cultivated [4]. Although this large uncultivated area still has a good potential to improve the food security of the country. Algeria has been using Agri-tech, where technological advancements such as the Internet of Things (IoT), wireless networks, Cloud computing, and Artificial Intelligence (AI) are utilized to improve the plants' and environment's health. For example, many organizations are joining forces to build smart solutions to help farmers achieve better quality and quantity of local products. Worldwide IoT Network Grid (WING) is an initiative of Nokia which aims to utilize IoT to reduce irrigation consumption in Algeria, in partnership with the mobile network operator Djezzy [5]. Other foundations are also starting their paths in this field, namely: "Filaha Innove", the Algerian senior experts' foundation launched in 2007 [6]. Its objective is to empower agri-tech innovation by organizing related events and accelerators. Encouraged by local accelerators like "Algeria Venture", several agri-tech Startups have been established by Algerian youth. For example, the Startup "AITech" uses sensors to collect, combine, and store data on the Cloud to provide deep insights for precision farming, including irrigation and weather forecasting, via web and mobile applications [7]. Further, the Startup "BIOFERTEC" monitors the use of fertilizers using data analytics. The Startup "GreenAI" proposes biodigester systems to reduce organic waste [8].

Green Algeria Project is an open-source project; by "Omdena Algeria Chapter" [9], a nonprofit organization, to help farmers manage their greenhouses by means of Machine Learning (ML) technologies. More than 50 collaborators were working together to tackle three main challenges in greenhouses: diseases and anomalies in plants, indoor climate factors monitoring, and responsible usage of water for irrigation. Computer vision, time series, and classification techniques were deployed to tackle each one of the challenges, respectively. All three solutions were grouped in one web application, offering the farmers an easy-to-use, AI-based tool [10]. Despite the potential of Agri-tech in Algeria, more work in terms of infrastructures, normalization, and investments needs to be fulfilled, giving more space for innovative and challenging solutions.

2.2 Egypt

For thousands of years, Ancient Egyptians recognized the close connection between the environment and human beings. The Great Nile despite being the lifeline for Egypt was also associated with diseases. Today with the fast-tracking of technology usage in medicine, it's vital to reconsider the concept of 'One Health'. With the digitization revolution in Egypt, this multidisciplinary concept of interconnecting humans with their environment, animals, and plants has been served.

Ain Shams University Virtual Hospital (AVH) in collaboration with the National Authority of Remote Sensing and Space sciences has developed a GIS model using ArcGIS software that had four geodatabases. One of which was specifically developed for socioeconomic and environmental parameters as LST (Localized Significant Thresholds) and PM10 (Particulate Matter) assessing risk areas for NCDs. The geodatabases are very important for decision-makers to detect the high-risk areas depending on a risk map. This can guide planning schools and houses away from pollution areas, detect sources of pollution, and provide specific medical services for areas of need. The model was applied to the catchment area of Ain Shams University Hospitals and can be replicated in any given area.

Telemedicine has positively contributed to the well-being of humans and the surrounding ecosystem in several ways. In Egypt, AVH has provided telemedicine services since 2016. It has substantially aided in the confinement of the Novel Coronavirus disease (COVID-19) pandemic and if implemented widely across human and animal medical care can limit zoonotic diseases too. In a world where climate change has been named as one of the biggest threats to human health, the healthcare sector continues to significantly contribute to greenhouse gas (GHG) emissions. Health Care Without Harm estimated the global carbon footprint of healthcare to be 2 gigatons of carbon dioxide equivalents (CO2e) in 2014, equating to 4.4% of global net emissions; transport contributed 7% of this total [11]. Therefore, telemedicine reduces the carbon footprint of healthcare, primarily by reduction in transport-associated emissions. The carbon footprint savings range between 0.70–372 kg CO2e per consultation. Egypt has 27 governorates with an aggregation of specialized healthcare services in large governorates as Cairo and Alexandria leading to a major increase in trans-governorate mobility and consequent increase in carbon dioxide emissions. AVH has also provided across border telemedicine both C2P and P2P and healthcare professional training further contributing to decreased patient mobility. Implementing the Health Information system in 2022 will allow AVH to identify the catchment area of ASU hospitals whether for physical or virtual healthcare services, hence estimating the decrease in carbon emissions with the use of telemedicine. Most recently, surgical interventions enabled via augmented reality are being piloted between AVH and Kafr Elsheikh hospital, one of the spokes linked to AVH network. This too can decrease the carbon footprint resulting from patient mobility between governorates.

The Ministry of Environment has implemented on its website a real-time pollution indicator available for the community. It can help those with respiratory allergies stay home or avoid areas of high PM10 pollution to prevent exacerbation of their chest conditions. Currently, a trial to integrate this with EMRs (electronic medical records) of patients to send targeted notifications to those with chest allergies when pollution increases are being planned [12].

2.3 Iran

In Iran, an integrated perspective on implementing 'One Health' using information and communication technology (ICT) requires further attention. So far, there have been several attempts for developing national electronic health records and implementing telemedicine services, particularly during COVID-19. Now, a more dynamic managerial approach is required to support 'One Health' strategy [13].

Although 'One Health' has not been fully operationalized in Iran like most other developing countries, a few attempts have been yet made to implement it in its practical form. These attempts, however, are scattered and have mainly focused on food safety, zoonotic diseases, laboratory services, environmental health, and antimicrobial resistance. In 2018, the United Nations Population Fund (UNFPA) country office in Iran conducted the 'One Health Tool Training for Economists and Public Health Scientists and Validation Workshop'. The main objective of the workshop was to build the capacity of health economists, public health scientists, academics, practitioners, and finance specialists on the application of the One-Health Tool [14]. Recently, Iran Veterinary Organization (IVO) implemented a geographic information system (GIS)-based animal disease surveillance system along with an integrated quarantine system to control diseases [15]. In the 'One Health' approach, integrating the zoonotic data may help to improve data availability and accessibility, which in turn, can facilitate preventing and controlling diseases. Developing a surveillance system for zoonotic diseases in the rural areas of the third largest province of Iran is an example of the efforts made in this area [16]. However, this system needs further improvements to be used as a national registry and integrated with other information systems. In another study, Shanbehzadeh et al. developed the zoonotic diseases minimum dataset (ZD-MDS) and mapped it to the structured clinical vocabularies. They used the health level seven-clinical document architecture (HL7-CDA) standard to define the interoperable and human-machine reporting template, too [17].

Overall, it seems that successful implementation of the 'One Health' approach in Iran requires a strong backbone and collaborative ecosystem for all possible agents, such as the Iranian Ministry of Health and Medical Education, the Ministry of Agriculture, the Iranian Veterinary Organization, and the Ministry of Labour and Social Welfare. This ecosystem should be supported by integrated programs, policies, practices, legislations, and research activities run by multi-sectors' stakeholders. Advanced information technology and AI can also be used to encompass all related disciplines including human health, animal health, and the surrounding environment. One of the possible barriers could be the unwillingness of different organizations to share their information [18]. Therefore, more efforts are required to set

information-sharing strategies and overcome information technology limitations [19] to support the foundation of the 'One Health' approach which includes high-quality data sharing. A number of other challenges such as lack of coordination at the national administrative levels, competing priorities, funding deficiencies [20], limited resources, inefficient health systems, and political issues [21] are also influential. Therefore, as an initial step for 'One Health' implementation, investigating the contextual challenges and facilitators at the national level is crucial.

2.4 Jordan

'One Health' is an embedded concept in many initiatives in Jordan, with technologies being a catalyst. One of these initiatives is the Jordan Environment Fund (JEF) by the Environment Protection Law of the Ministry of Environment to help Jordan advance its national goals for environmental protection and sustainable development. Many projects were supported by JEF in diverse sectors in diverse areas and locations across Jordan, including but not limited: (1) deployment of drone technology to enable the environmental police to better monitor and address forest violations and respond to fire hazards, (2) installation of Global Positioning System (GPS) tracking systems on hazardous wastewater transportation tankers in order to track violators and take corrective measures, (3) development of the first interactive gaming app to raise awareness of youth (ages 6-15) about waste reduction and recycling (EcoChamp); and (4) translation of the first course on climate change to the Arabic language, available online through thr United Nations Institute of Training and Research (UNITAR), in collaboration with EDAMA [22].

Jordan has also been employing technologies in the agriculture sector with the transition to a climate-resilient growth path. Specifically, given climate change and its consequences on agricultural production, the Ministry of Agriculture has employed Climate Smart Agriculture (CSA) [23]. The aim of CSA is to: (1) expand and upgrade the protected vegetable production with advanced technologies and processing and marketing options (irrigated areas), (2) upgrade olive production and process by introducing low-cost modern technologies for collection, cold pressing, and pickling, (3) strengthen the energy-water-food nexus in irrigated agriculture by replacing fossil fuel for pumps and local desalination units with renewable solar energy, and (4) expand and upgrade the protected vegetable production with drip irrigation and improved greenhouse technologies [23]. The private sector has also implemented many initiatives related to agriculture. For example, electronic programs were designed to control irrigation, fertilization, temperature, and humidity in farms in Deir Alla (Balqa), Giza (Amman), and Northern Shuna (Irbid) [24].

As a result of the accelerated growth of digital technology and AI capabilities, digital technology and transformation have been employed in many sectors in Jordan (*e.g.*, health, education, and agriculture). Though, they are not being employed equally in all sectors. For example, digital technology in the agricultural sector is still lagging behind the rest of the sectors. The agricultural sector in Jordan is classified as an informal sector and needs to be formalized and institutional at all levels. Digital technology and transformation in Jordan led to the development of many services provided digitally using mobiles. In turn, this can decrease the need to travel to governmental institutes, thereby, reducing traffic jams and air pollution.

2.5 Kuwait

Kuwait's Vision 2035 incorporated the concept of 'One Health' in many of its pillars and strategic directions [25]. Kuwait is working toward transforming various sectors and industries including health, energy, environment, food production, and information technology. From an environmental perspective, and in line with Kuwait's Vision 2035, the Environment Public Authority (EPA) established the Environmental Monitoring Information System (eMISK), one of the largest environmental databases in Kuwait. eMISK leverages geographic information systems and remote sensing to support evidence-based environmental decision-making for waste management, the marine environment, drinking water, air quality, energy, land, and biological diversity [26, 27]. Another initiative by Kuwait's EPA is "Beatona", which is part of its eMISK developed "with the sole intention of generating awareness and sharing authentic contents and valued scientific information in a user friendly manner" [28]. Additionally, Kuwait's Vision 2035 promotes sustainable food production while integrating sustainability and economic feasibility using adaptable technologies in desert regions and alternative resources for agricultural production [25]. Based on that, Kuwait's Institute for Scientific Research (KISR) aims to optimize and demonstrate best practices and technologies for sustainable and enhanced food production [29].

Evidence suggests that knowledge sharing and data management are fundamentally rooted in 'One Health' approaches [30]. Kuwait was successful in implementing ICD-11 "for documenting final diagnoses by physicians in the outpatient and inpatient wards in one of the largest public hospitals" [31]. Recently, Kuwait's Ministry of Health (MoH) initiated collaboration with the Healthcare Information and Management Systems Society (HIMSS) to assess the public healthcare system's performance by using the Electronic Medical Record Adoption Model (EMRAM). This model includes 8 stages (0-7) and allows measuring the adoption and utilization of Electronic Medical Records (EMR) in the different public healthcare institutions. Members of the Kuwait Health Informatics Association (KHIA) participated and facilitated these efforts to include both hospitals and primary care centers across Kuwait. The results of the evaluation will soon be published. Moreover, two private hospitals in Kuwait achieved levels 6 & 7 and are the first to achieve this on a national level.

2.6 Morocco

Morocco has a set of endemic ecosystems with remarkable flora and faunal biodiversity. The flora is characterized by high vascular plant diversity, with an estimated 4,200 species and subspecies, of which 22% are endemic [32]. The fauna has over 25,000 known species, with 11% indigenous,

and comprises 113 mammals, 317 birds, 98 reptiles, 11 amphibians, 1,189 fishes, and 17,893 invertebrates [33, 34]. The most frequent emerging diseases in Morocco are transmitted by insect vectors, such as West Nile fever, a disease whose reservoir is birds and, more specifically, migratory birds, which is common to humans and horses. Other examples include the H1N1 flu that appeared in 2009 and low pathogenic avian influenza in 2016. Two purely animal diseases, bluetongue, which is a vector-borne disease, appeared in 2005, against which we continue to vaccinate livestock in Morocco. Finally, "peste des petits ruminants" (PPR), a cross-border illness, occurred in 2008 against which Moroccan livestock are still being vaccinated [35]. An upsurge in zoonoses is due to encroachment on wildlife habitats, which promotes the transmission of animal diseases to humans, and to global warming, which enables the multiplication and adaptation of pathogens and vectors of transmission of zoonoses.

In 2020, Morocco demonstrated its willingness to contribute to the success of the "ZODIAC" initiative (integrated action against zoonoses) within the framework of its partnership with the International Atomic Energy Agency (IAEA) in a perspective resolutely oriented toward Africa. ''ZODIAC" (Zoonotic Disease Integrated Action Project Early Detection and Global Response) encompasses five pillars aimed at strengthening regional and national capacities for diagnosis and detection, provision of new technologies for the detection and monitoring of zoonotic diseases, development of real-time decision support tools for timely intervention, access to data relating to the impact of zoonotic diseases on human health, and establishment of a team for a coordinated response led by the Zoonoses Agency [36].

The establishment of a pilot Health and Environment Information System (SISE) is one of the priorities of the "National Health and Environment Action Plan" for better consideration of health and environmental issues. This system aims to strengthen existing regional systems for monitoring and analyzing ecological nuisances (Regional Environmental Information Systems (REIS)) and to supplement them in aspects relating to the monitoring and evaluation of health impacts, to help decision-making on appropriate impact reduction measures and to guide prevention efforts [37]. In addition, within the frame of the European-funded project 'One Health' Next Scientific Generation in the Sahel and Maghreb" (OH-Nextgen), a web-based 'One Health' course was introduced and followed by a group of junior veterinarians, biologists, and doctors.

It is worth mentioning that there is a pool of innovators developing digital solutions that promote ecological growth and better respect biodiversity in Mediterranean countries, including Morocco. By providing early flood predictions and alerts, the startup Prev-Dev in Morocco improves city and citizen resilience to environmental disasters and life security [38]. Valeur-Tech works for the digital and food sovereignty of Mediterranean countries by creating an ecosystem of transversal skills in the management of technology and innovation paired with "business" skills specializing in sectors such as field crops, cattle, and vineyards [39].

To further promote the 'One Health' concept and agenda in Morocco, a multidisciplinary team of human-, animal-, and environmental-health professionals established the "One Health Morocco" association in November 2019. Prospects for establishing a platform supported by the association and all parties participating in the 'One Health' concept are being explored.

2.7 Pakistan

In Pakistan, the use of ICT seems to have fragmented footprints, implemented in various sectors with a narrow focus on 'One Health' that requires a transdisciplinary, multisectoral, and collaborative approach working at the local, regional, national, and global levels to achieve optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment.

Pakistan has shown good progress in digital healthcare and climate change action under UN Sustainable Development Goal (SDG)-3 and SDG-13 with improvement in basic indicators [40]. AI-based systems for healthcare can improve public health in response to climate-related pandemics. In the wake of disasters such as floods, earthquakes, and storms, AI systems can generate threat alerts by updating maps and identifying high-risk communities.

Climate change poses a major threat to the operation of global health systems, triggering large-scale health events, and disrupting normal system operation. Digital health may have a role in the management of such challenges and the reduction of greenhouse gas emissions. Digital health has the potential to reduce health system greenhouse gas emissions, for example by shifting to virtual services. It can assist in managing changing patterns of infectious diseases as well as environmental health events by timely detection, reducing exposure to risk factors, and facilitating the delivery of care to under-resourced areas [41].

Pakistan is devastated by the worst flood in recent history due to rapid climate change. Recently, one third of the country was under flood while affecting more than 33 million people along with 1,700 causalities and approximately 20 billion USD economy loss. AI has huge potential to overcome such losses by developing intelligent systems for early prediction of such floods, risk assessment, and management [42]. Recently, the development of AI-based earthquake prediction systems has also improved the prediction and assessment of earthquakes in Pakistan [43].

Among South Asia's most urbanized countries, Pakistan suffers from severe urban air pollution, which negatively impacts the quality of life, human health, the economy, and the environment. Air quality improvements in Pakistan can have significant economic and health benefits. The deployment of an AI-based distributed sensor network system to monitor, analyze and predict air pollution, is helping to reduce air pollution and ultimately improving human health. In line with SDG-13, Pakistan has successfully implemented four years 10 billion Tree Sunami Project (2019-2023) to address SDG-13 and combat climate challenges. Pakistan Telecommunication Authority in collaboration with mobile operators is operating an early warning system to communicate with disaster-vulnerable communities [44].

Digital health technologies have been successfully employed to control the COVID-19 pandemic. COVID-19 statistics dashboard

and a mobile application "Pak Neghayban" is developed for healthcare managers and people to check the availability of ventilators and beds for COVID-19 patients [45]. In spite of rapid growth in digital health startups, there are several challenges that are affecting the growth of the digital healthcare ecosystem in Pakistan. Some of them are lack of Infrastructure, low e-literacy rate, poor quality of available data, data security, and privacy [45].

2.8 Palestine

The 'One Health' approach has a very limited implementation in Palestine facing several challenges [46, 47]. The importance of adopting the approach at a national level became significant after the impact of COVID-19 on Palestinian society in several aspects including health, economic, and food security [47, 48]. While veterinary control, climate change, and food security and safety played a role in emphasizing the need for implementing the 'One Health' approach, COVID-19 demonstrated the risks of zoonotic diseases and their potential impact on the whole society as an epidemic. As a response, various organizations, governmental and non-governmental, including WHO [47], attempted to define work and coordination plans to bring about a joint effort in Palestine. However, as of writing this work, these did not translate into tangible implementation steps or systems.

A qualitative study conducted in Palestine revealed the barriers to implementing 'One Health' surveillance systems for controlling zoonotic diseases, like COVID-19. Four key findings were identified. They consist of poor multi-sectorial policy coherence, insufficient funding on 'One Health', weak governance and leadership, and insufficient training programs for 'One Health'. Miserably, the policies of Israel's Occupation hinder the development of the Palestinian information and communication technology sector through a number of strategies, including information dominance and submission to the terms of unfair agreements. These restrictions are the result of colonial political aims to limit and stifle development and hinder the expansion of Palestinians' capacity for innovation in technology [49, 50].

Despite the absence of effective 'One Health' surveillance systems for controlling zoonotic diseases in Palestine [46], there are fragmented initiatives and responses that reflect a positive attitude of the Palestinian community to work according to 'One Health' basics [51]. A considerable initiative from the health sector has been established since the COVID-19 virus outbreak in Palestine. The Palestinian National Institute of Public Health (PNIPH) worked with the Ministry of Health (MOH) and the District Health Information System 2 (DHIS2) country team to create the national COVID-19 surveillance system based on the already-existing free and open DHIS2 software. The system incorporates Palestinian case management standards and procedures in addition to the WHO case definition and reporting form. The software can generate the statistics and indicators needed for follow-up and monitoring the containment or spread of the outbreak, and it can give real-time assessments [52-54]. Additionally, the Ministry of Telecommunication and Information Technology (MTIT) has got a significant role during the outbreak in Palestine. It has supported MoH by preparing a virtual environment for remote meetings to enable government staff to meet and work remotely. Also, hosting for 24 websites to facilitate working during the emergency and hosting for "Sehhaty" application of the Ministry of Health, which deals with the emergency of COVID-19 cases.

Related to the environmental sector, using of ICT has been mainly in facilitating the communication of environmental services providers with the community through social media, web pages, and mobile applications. Also, municipalities pay attention to raising awareness of people about different environmental issues like solid waste collection by making and publishing video clips on their YouTube channels and Facebook [55, 56]. The Joint Service Council of Wadi Gaza (JSC-WG) is in charge of developing Wadi Gaza as a natural reservation area. The council's primary responsibilities are to protect, maintain, and develop the reservation area. Through publishing video clips and using the website, the joint council is making efforts to highlight the idea of the project ensuring safe waste disposal practices, which includes cleaning up the Wadi and ending future pollution of the Wadi [57, 58].

Moreover, the ministry of education in Palestine has motivated students to participate in finding solutions for environmental issues through using ICT. Recently, The Innovation for Creativity Development foundation announced that a governmental secondary school for girls from Palestine won first place at the level of the Arab world in the first edition of the Future Scientists Competition 2022. The winning project is a boat-shaped robot that uses AI to clean the water environment without the need for human workers to go to those places [59].

2.9 Qatar

In 2021, Qatar's cabinet endorsed the National Climate Change Plan (NCCP) to reflect the country's long-term sustainability ambitions to respond to the climate crisis effectively. Qatar's commitment to combat climate change is outlined in the NCCP, which includes strengthening capabilities, diversifying the economy, and optimizing the use of natural resources [60].

In response to the emerging challenges, Qatar launched national development programs like Tarsheed in 2012 [61]. Tarsheed is mandated by electricity and water consumption law no. 20 for 2015 to regulate and monitor energy efficiency and consumption in Qatar. In 2020, Tarsheed program reduced water consumption by 32 million m^3, electricity by 289 GWh, and natural gas by 3,207 MCF, representing a saving of $83m [61]. Tarsheed launched an energy-efficiency smart online platform and mobile application in November 2021. The new applications aid to reduce residential energy consumption by 5%. The application assists customers in developing a standard consumption plan based on the consumers' needs, as well as proposing a smart plan to achieve the targeted energy reduction. In addition, the platform assists all subscribers in learning about and comparing their consumption, working toward energy efficiency, and saving money. Furthermore, subscribers who use the platform can also earn "sustainability points", which could be redeemed as incentives in collaboration with business partners [62].

The design, planning, and execution of the FIFA™ World Cup Qatar 2022 take sustainability into account. Using AI technologies,

stadium infrastructure was designed to be environment-friendly by using 40% less water and 30% less energy during operations [63]. Qatar also launched a plan in 2021 for air quality monitoring in training grounds and stadiums during the FIFA™ World Cup 2022. Two air quality monitoring stations have been completed and are now operational at Al Janoub and Al Thumama stadiums. During the FIFA™ World Cup 2022, AI advanced technologies are predicting crowd flows to help in quickly dealing with any overcrowding. AI experts can identify bottlenecks, monitor the performance of entry gates, predict crowd swells, and ensure that people flow smoothly into and out of stadiums [64].

Qatar has implemented cutting-edge cooling technology in Lusail city to save more than 65 million tons of CO_2 per year. This helps to reduce the negative ozone layer effects that would otherwise be observed when using several small electrical units [63]. Moreover, the Ministry of Municipality and Environment (MME) has launched a mobile station to monitor ambient air quality at the vehicle vaccination service center against COVID-19 in Lusail city [65]. This is to monitor and control the ambient air around the clock continuously. These efforts come within the framework of keenness to ensure the air quality in Qatar following the highest international standards [65].

A national network for continuous air quality monitoring of seawater quality using advanced technologies has been established. Continuous implementation of 5 air, water, and soil monitoring programs is carried out at the state level [66]. The governmental authorities in the country put a comprehensive plan to monitor the quality of coastal and marine waters and air quality. The buoys and stations were equipped with advanced detectors for continuous environmental monitoring. This is expected to provide an early warning of any pollution or disruption of the marine environment and air quality by monitoring indicators and preliminary data measured by the devices in the buoys and stations throughout the day, allowing decision-makers to respond to and intervene in the event of potential contamination [67].

Qatar has made global achievements in all fields related to radiation and hazardous materials protection by having a regional laboratory specialized in radiological measurements in addition to an integrated national-wide project with a radiation monitoring alarm network [68]. Further, Qatar's participation in the "Plant a Sensor" campaign, coordinated by the World Green Building Council (WGBC) and other partners, is one of the most recent initiatives [69]. Qatar Green Building Council (QGBC) has installed 20 air-quality monitors in public schools, malls, health facilities, and residentials. These will be connected to a global network in 30 countries with over 1,000 sites, providing real-time intelligence on building performance to improve environmental sustainability and health [70]. Additionally, a national database has also been developed and operated to monitor and analyze fisheries statistics for all fish landing sites in the country, and the database has been linked to the international information network [71, 72].

Qatar is meeting its international environmental obligations and has the potential to become a global leader in environmental protection. Many initiatives are being implemented in the city of Doha, such as plans to treat urban water sources, provide a biodiversity database, and a regional program for monitoring air quality. The city will likely become a global center for environmental research and innovation.

2.10 Saudi Arabia

Saudi Arabia launched the ambitious Green Riyadh project in March 2019 to raise the per capita share of the green area in the city, enhance the city's air quality, reduce the city's temperature by 1.5-2%, and reduce energy consumption by 650 GWh [73]. The Green Riyadh project will improve quality of life indicators in the city, establish open areas for practicing various sports, and increase walking rates for individuals, thereby, improving the population's health [73].

Saudi Arabia launched the Saudi Green Initiative to reduce carbon emissions by 278 million tons annually through many ambitious programs such as investing in new energy sources (e.g., wind and solar energy), enhancing energy efficiency, and scaling up carbon capture and storage programs [73]. Saudi Arabia can reach its climate goals and achieve zero neutrality through these initiatives and programs by 2060 [73].

Saudi Arabia authorities announced and led the Middle East Green Initiative in 2021 [74]. This initiative aims to restore vital environmental functions, improve air quality, and reduce dust and sand storms [74]. The approved afforestation initiatives are planned to be implemented over the coming decades. A comprehensive framework was designed to achieve the target of planting 50 billion trees, 10 billion trees in Saudi Arabia, and 40 billion trees in the Middle East [74].

The Green Riyad project, Green Saudi and Middle East initiatives are implementing technology for an ecosystem of planting, monitoring, and irrigating. AI and Internet of Things devices and sensors will reduce inefficient irrigation by monitoring climate conditions and soil moisture to require the needed amount to water trees. Drones will play an increasingly important role in inspection and environmental monitoring through crop and tree spraying and monitoring, maximizing seed pollination, livestock monitoring, and collecting soil data [73, 74].

As part of the "Saudi Vision 2030" plan, NEOM, the Saudi future smart city, has a remarkable opportunity to become the first capital of health technology and a global center for innovation and collaboration in health services and wellness technology through automation and digitalization. NEOM aims to establish an integrated system for the health and biotechnology sector that goes beyond traditional healthcare by relying on innovative technologies, research, and education to provide advanced and comprehensive care [75].

NEOM is working on designing a digital-first ecosystem, Dr. NEOM system, that will be available around the clock [75]. Dr. NEOM will combine AI algorithms with genetics and smart technology to offer "digital twins" for each patient to advise on vital signs or remind a patient of checkups. Dr. NEOM will connect patients to virtual healthcare providers in real-time. Also, it will use AI algorithms for patient triage to prioritize patients' medical urgency and the Internet of Things devices to monitor patients' vital signs to send patients' real-time data remotely to healthcare providers [75].

This level of communication and interaction allows healthcare providers to make early interventions to improve patients' healthcare services and outcomes.

2.11 United Arab Emirates

Like other countries, the United Arab Emirates (UAE) is committed to taking serious actions to address 'One Health' issues. Meanwhile, the UAE is using AI techniques to analyze various types of animal diseases and develop an intelligent inspection algorithm for food establishments. In addition, the Abu Dhabi Agriculture and Food Safety Authority (ADAFSA) launched the Food Import and Export Management Information System (FIEMIS) during its participation in GITEX Technology Week 2022. FIEMIS enables key ADAFSA functions to be completed online, such as food importer registration, imported food registration, food import application, and inspection of food shipments from other emirates to ensure food safety during import and export processes [76]. FIEMIS includes a food safety dashboard that displays food alerts issued by regional and international authorities and provides strict control over non-compliant food products. Users of the system can also contact the relevant food companies to recall non-compliant products.

Despite technological development, reliance on paper made from trees and unplanned agriculture contribute to the destruction of more than 15 billion trees per year and lead to more air pollution from carbon monoxide, exacerbating global warming and nature's regression [77]. The digital transformation that the UAE has experienced in recent years has contributed to reducing the depletion of trees to process millions of paper-based transactions each year, creating a cleaner, oxygen-rich atmosphere that has a positive impact on human and animal health. For example, a report by The Economist ranks Dubai as the 18th most digitized city in the world [78]. In addition, the UAE has a comprehensive health informatics platform that supports the entire continuum of healthcare in the UAE. For instance, as of April 2021, 95% of all hospitals in Abu Dhabi were connected to Malaffi. Malaffi connects more than 2,000 healthcare providers from the public and private sectors in Abu Dhabi alone [79]. At the strategic level, the Ministry of Health and Prevention (MoHAP), in collaboration with the WHO Regional Office for the Eastern Mediterranean in Dubai, recently organized a national workshop focused on the 'One Health' approach, an integrated, unifying tool for joint assessment and control of zoonotic diseases. The UAE supports the 'One Health' approach and integrates it into its strategies. To achieve this goal, the Ministry of Climate Change and Environment is working with public and commercial sector partners to support national efforts through a variety of strategies, such as leveraging cutting-edge technologies and techniques and adopting best practices [80]. These include creating and improving national air pollution standards and monitoring compliance, transitioning to a green economy and increasing the use of clean energy in various industries, improving sustainability in the transportation sector, creating an air quality monitoring network, and deploying smart technologies and solutions to monitor various types of pollutants. This compilation is part of 'One Health' UAE's efforts to effectively identify common problems, develop the appropriate national plans, prepare for future threats and mitigate their consequences, taking into account the important role of health informatics and new data sciences to promote 'One Health' approach.

Despite low rainfall, high temperatures, poor soil, and lack of natural waterways, the UAE has also made outstanding efforts over the years to develop an agricultural sector that is better able to contribute to food diversity and the national economy by adopting policies that limit the effect of the above-mentioned issues and adopt sustainable and climate-smart agriculture methods that concentrate on the optimal utilization of the cultivated land and the quality of local produce to enhance food diversity. These regulations typically rest on cutting-edge technologies such as hydroponics, aquaponics, and organic agriculture.

3 Conclusion

'One Health' is becoming a reality rather than a concept that countries are practicing to achieve Universal Health Coverage. It has become clear that countries are lacking full integration between the different authorities taking care of human health and the health of animals and the environment. The different presentations by countries showed that the way to make sure that human health is of prime importance to all is through the integration and interoperability of systems that record and share data. This interoperability of data is very far from using one system to cover all aspects of health. It's a call to use standards to share data on a regular basis and when there is an emergency.

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