World Health Organization
REGIONAL OFFICE FOR THE Eastern Mediterranean

TECHNICAL WORKSHOP TO ESTABLISH GENOMIC SURVEILLANCE NETWORK IN THE EASTERN MEDITERRANEAN REGION FOR EMERGING & RE-EMERGING INFECTIOUS DISEASES,

AMMAN, JORDAN

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Meeting Report

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1. Executive Summary

The WHO Eastern Mediterranean Regional Office (WHO/EMRO) Infectious Hazard Preparedness Laboratory team organized a technical workshop to seek regional input into a strategy for establishing a genomic surveillance network for emerging and re-emerging pathogens in the Eastern Mediterranean region. The meeting brought together a broad range of stakeholders from national, regional and international platforms, including institute directors from human and veterinary health departments, laboratory, surveillance and epidemiology experts, policy makers, donors and representatives from regional and UN entities including the Food and Agriculture Office (FAO) and World Organization for Animal Health (WOAH).

The objective of the meeting was to consult with these expert stakeholders on the scope, terms of reference, objectives and implementation of the genomics surveillance strategy, and identify the critical areas of support that the network should address. Multi-level and cross-sectoral discussion was encouraged, to ensure a broad range of inputs could be consolidated into the strategy, aiming to ensure tangible interventions and support that would work at all levels of the network to support expansion and sustainability of genomic surveillance establishing during the COVID-19 pandemic and as part of the Global Influenza Surveillance Service (GISRS).

The outcomes of this consultation will be collated and key findings incorporated into the regional strategy for genomic surveillance, and inform the development of the network to ensure it is sustainable and fit-for-purpose. The meeting consisted of plenary sessions from international and national experts on existing pathogen surveillance networks, data sharing, and data platforms used to inform public health outcomes.

These sessions were paired with guided group discussions covering the vision for the genomic surveillance network, opportunities and challenges with data sharing in the region, integration of genomics with traditional surveillance networks to support public health interventions, and the tangible details of how a regional genomics network should operate to best support national and regional public health, and provide high quality data to international networks and responses.

Group discussions were open and informative, with over 200 suggestions and recommendations gathered across the four sessions. Major themes emerged including lack of visibility, coordination and support for logistics, training and expansion into new pathogens, lack of expertise in novel and emerging pathogen surveillance, and challenges with infrastructure to support data analysis, sharing and outputs.

Key Recommendations

Key recommendation were collated and will be reviewed for inclusion in the regional strategy document. These include the implementation of a high-level steering committee, supported by multi-national, cross-sectoral technical pillars addressing the challenges faced by the member states and the region.

Pillars include technical working groups supporting harmonization of operating procedures and protocols, standardization of training and risk assessments, improved data sharing, awareness and visibility of genomics programs across the region, improved quality management, monitoring and evaluation to ensure workforce sustainability, and improved coordination and advocacy for cross-border, multi-sectoral collaborations for health interventions and research in the region.

The need for tangible support in these areas will be critical to the success and engagement with the network, while advocacy at the regional level will be needed to encourage stakeholders and build trust in genomic surveillance as a tool to support public health responses.

2. Background

The growing understanding of genomic sequencing information and rapid availability of viral sequences makes genomic sequencing an important tool for disease surveillance [1]. Timely and in-depth pathogen characterization supports public health interventions, allowing for targeted and effective control of disease outbreaks [2-6]. Genomic sequences can also help with the design and quality control of diagnostic assays, drugs, and vaccines by monitoring changes in the virus genome caused by evolutionary dynamics that may affect efficacy [7-12].

Whole genome sequencing (WGS) of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has been a powerful tool to monitor SARS-CoV-2 since the first sequence was published on January 10, 2020 [14,15]. The analysis of SARS-CoV-2 using robust and increasingly affordable next-generation sequencing (NGS) technologies [13] has been used to complement, augment and support strategies to reduce the burden of COVID-19 [16, 17], and continues to inform improved public health policies through monitoring, detection and characterization of SARS-CoV-2 variants.

In May 2021, the World Health Assembly (WHA) urged countries to increase their capacity to detect new threats beyond COVID-19, including through laboratory techniques such as genomic sequencing [18]. Recognizing the global momentum and drive for investment and continual improvements in the cost, ease, and speed of sequencing [19], WHO released the Global genomic surveillance strategy for pathogens with pandemic and epidemic potential, a 10-year roadmap to support the expansion and integration of genomics into national, regional and international pathogen surveillance programs (ref).

The WHO/ Eastern Mediterranean Region (EMR) comprises the occupied Palestinian territory and twenty-one Member States: Afghanistan, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Somalia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates and Yemen. They have diverse cultures, socio-economic conditions, and demographic characteristics. The provision of health and other services in the region is challenging due to acute and protracted humanitarian emergencies, poverty, political instability and fragile health systems [22-24].

WHO Regional Office of the Eastern Mediterranean (WHO/EMRO) is coordinating the development of a regional strategy aimed at providing a high-level vision to strengthen, scale, and integrate genomic surveillance with traditional pathogen surveillance networks, in line with the global strategy. This will facilitate improved public health responses to emerging or re-emerging pathogens with pandemic potential [20,21], and integration of sustainable genomic surveillance into existing pathogen surveillance networks.

The strategy aims to provide guidance for developing a multi-sectoral, cross-cutting network coordinating pathogen sequencing and bioinformatics, sharing of data and capacity, with the goal of improved integration of genomics with existing surveillance networks to facilitate public health decision making in the EMR. It will provide guidance and tangible support for continued expansion of sequencing capacity and expertise, both national and regional, improved logistics and coordination of responses to pathogens as they emerge. Improved visibility and understanding of how genomics data can support traditional epidemiology will build trust in genomics, and help sustain investment in the longer term.

A key lesson from the COVID-19 pandemic is that pathogens can emerge from nature more at any time(ref). The sequencing strategy needs to incorporate a one health approach, to improve linkage between sectors, including human, veterinary, food health and social platforms, ensuring that genomic information is drawing on a wide network of sampling strategies, improving surveillance outcomes (ref). A landscape review, including assessing both the genomics and surveillance capacity in the region will target areas of strength and areas that can be supported for improvement through investment or further training.

The strategy will aim to clearly define roles for member states, stakeholders and the network as a whole, with clearly defined terms of reference, aims and key performance indicators to define the success and sustainability of the network in the longer term. It will build on existing infrastructure including hub-and-spoke laboratories, and will investigate novel mechanisms for expanding capacity and sharing knowledge, including member state twinning initiatives, along with continued partnership with international stakeholders, to ensure the network is agile and able to respond to crises as they emerge, instead of retrospectively. The implementation of the strategy

will be a multi-step, stakeholder and member state led process, producing an agile, sustainable network that can respond to pathogens before they become epidemics or pandemics.

3. Meeting Goals and expected outcomes

Specifically the meeting aimed to gather feedback from cross-sectoral collaborators to:

- Establish a vision for the EMR Genomic Surveillance Network for pathogens with pandemic and epidemic potential.
- Identify challenges with building, supporting and expanding national and regional capacity for genomic surveillance in EMR.
- Identify the challenges and opportunities presented to the network to support and improve cross-sectoral data sharing between laboratories, public health authorities and stakeholders regionally and globally.
- Discuss and identify functional mechanisms and outputs of the EMR Genomic Surveillance Network, ensuring high quality data contributions to regional and international databases supporting public health responses.

At the end of this meeting, the organizers will collate recommendations and feedback to support the following aims:

- Establishment of a vision and framework for effective operation of the Genomic Surveillance Network in the EMR to support public health responses and interventions, both regionally and globally.

- Establishment or identification data management mechanisms that will improve data analysis and sharing between laboratories (human and veterinary), surveillance officers and public health offices to ensure integration of genomic data into public health responses.

- Establishment of guidelines, best practices and protocols for laboratories, minimal standards for data sharing and metadata collection, staff training and assessment, and quality assurance mechanisms to ensure high-quality and sustainable operation of the network in the longer term.

The meeting was structured as a hybrid between speakers and group work. Plenary speakers were invited to illustrate use cases, challenges and successes, nationally, regionally and internationally for implementation of genomics surveillance informing public health. These plenary sessions were paired with interactive group work to address specific goals and challenges that could be addressed by the network. Plenaries were delivered by international partner organizations, including New Variant Assessment Platform (NVAP), UK Health Security Agency (UKHSA), Rockefeller Foundation, US Center for Disease Control and Prevention (US CDC/Atlanta), demonstrating expertise and continued support of the regional network. Speakers from National laboratories in Oman, UAE and Morocco, illustrated the successes and challenges faced in scaling up genomics capacity and pairing with surveillance networks to support public health outputs in reference laboratories, both during and prior to the COVID-19 pandemic.

4. Plenary Sessions

4. 1 Session 1: Pathogen surveillance networks-Global and Regional Overview

The opening session of the meeting brought together international and national experts in the establishment, operation and sustainability of pathogen surveillance networks.

Dr. Maria van Kerkhove, technical lead for the WHO COVID-19 response, provided an overview of experiences during the pandemic response, illustrating the importance of genomics for controlling the pandemic, and focusing on the need to continually build on existing capacity and expand surveillance at the human/animal interface, as vector borne zoonotic diseases are both current and emerging threats to global health. The talk illustrated that complacency can become a problem during sustained pandemic responses, with genomic surveillance for COVID-19 dropping sharply in recent months compared to early in the COVID-19 response, and stressed the importance

of detecting and responding to emerging pathogens early, to prevent outbreaks becoming pandemics in future, and emphasizing WHO support for continual improvement in surveillance.

Kay van der Horst and Krista Mizenko from the Rockefeller Foundation reiterated the Foundations continued support for developing genomic surveillance capacity in the region, and gave an overview of how data can be shared and used in decentralized networks to build models for predicting outbreaks and how interventions can impact severity and duration of outbreaks. Rockefeller supported the establishment of a prediction network in Brazil, South America, with the talk illustrating that cloud based sharing and analysis of the data could provide accurate estimations of arboviral infection peaks and troughs, and how merging of social and population data can improve outbreak modelling and response. Insight into the benefits and challenges of data sharing through the cloud, including infrastructure and data security, and quality data can impact analyses.

Dr Gina Samaan from WHO HQ Laboratory Readiness and Response, presented an overview of the global genomics strategy, emphasizing the challenges and successes achieved so far. Dr Samaan emphasized the achievement of EMR in expanding capacity to over 90% of the region as a global success story, and congratulated member states. The Global Genomic Strategy sets a 10-year unifying framework to strengthen country, regional and global dynamic surveillance, highlighting that genomics is one pillar of surveillance, it needs to be integrated into the broader narrative and normalized as a key tool supporting epidemiological responses. Regions are encouraged to use the strategy as a framework for developing their own networks, to ensure continued global cooperation in the aftermath of COVID-19, and to improve responsiveness when the next outbreak emerges. Dr Samaan advocated strongly for the network to follow the five key principles of accessibility of tools and technology, a sustainable workforce with expertise in genomic surveillance, enhanced data sharing and analysis to support decision making, connectivity between genomics and existing systems and mechanisms, and maintenance of a readiness posture, to ensure that the network is agile enough to respond to emerging disease.

Dr Amal Barakat, laboratory lead from WHO/EMRO Dr Barakat presented an overview of the existing laboratory capacity in the region, illustrating that while there are diverse capacities, ranging from state of the art high throughput laboratories to smaller, sub-national groups, there is now almost universal capacity in the region to support genomics. This was a success from the regional perspective, improving laboratory capacity from almost nil, to almost total, including 3 state-of-the-art reference laboratories supporting the region. Expanding on this existing capacity for COVID-19 and influenza genomics is a key aspect of for WHO/EMRO, looking to add surveillance capacity for priority diseases in the region, including viral hemorrhagic fevers, vector-borne and water-borne diseases and emerging zoonoses, and making sure key pathogens are emphasized in each country. An explanation on the challenges facing this network, including humanitarian and logistical issues, such as the cost of machines and licensing, distribution of reagents, and more were also key factors of the talk. Dr Barakat then presented an overview of the intended purpose of the meeting, focusing on the goals and expected outcomes, and expanding on the need for input for members from all levels of the network to ensure the strategy is fit for purpose.

Dr Todd Davis from CDC Atlanta, next presented the role that CDC plays in genomic surveillance and discussed the drivers of pandemics, including spillover of zoonotic pathogens, climate change, intensification of animal production systems, vector proliferation and more. This multi-factorial increase in risk factors requires a multi-sectoral response to ensure that issues are detected in a timely manner. The utility of genomic data beyond surveillance was discussed, including vaccine development, giving an example of how CDC works with partners to produce annual vaccine and antiviral responses. CDC supports global influenza responses directly through the International Reagent Repository, producing and distributing kits globally, and providing monitoring and support to the GISRS network. He reiterated that a key aspect of genomic response is the timely sharing of high quality data, and discussed the challenges this presents at the state level in the USA, and how this can be addressed at the international level. He also outlined some of the capacity that the CDC supports globally and nationally including genotype-to-phenotype pipelines, where sequencing data can be rapidly expressed in wet-lab scenarios to establish whether genomic changes have an impact on virus replication, spread or response to antivirals or

vaccines. He ended by highlighting that these genomic networks form a pillar of the US disease network for diseases and are becoming increasingly complex and integrated into national responses.

The next series of talks were presentations from national surveillance networks in Africa through the African CDC (Dr. Gerald Mboowa), Morocco (Dr Elmir Elharti), UAE ( ) and Oman (Dr Hanan Al-kindi). The goal of these talks was to discuss systems and responses that had met with success during the pandemic, and to address some of the challenges that were faced in establishing these networks.

Dr Mboowa discussed successes in the implementation of COVID-19 genetic surveillance, improving regional coverage from 7 countries with sequencing capacity to 39 countries, with almost universal coverage of the AFRO region. He emphasized that this was a collaborative process between the Africa CDC, WHO/AFRO and stakeholders including the Gates Foundation, World Bank and other contributors. Support in the form of equipment, training, logistics, and bioinformatics and data analysis were the cornerstone of the development, all of which is now forming the basis of expanded genomic surveillance for priority pathogens in the region. One of the biggest challenges faced is the scale of the data generated, as secure and sustainable storage and analysis of genomic datasets is resource intensive, as well as continued coordination and maintenance of such a widely distributed network of laboratories.

Dr Elharti presented the development of the COVID-19 surveillance network in Morocco, which at the time of presenting had tested ~13 million tests, identifying ~1.3 million positive cases. Sequencing capacity intiitally was in the Pasteur Institute and the Ministry of Health National Public Health Laboratory, but due to the surge in testing needed, the ministry supported the decentralization of testing to a network of academic, hospital, provincial and private laboratories across the country. This means Morocco has a network of 24 laboratories across sectors supporting testing, which was leveraged to respond to other pathogens including MPOX, influenza and RSV. The ministry has also supported the establishment of a consortium for genomic surveillance again comprising multi-sectoral laboratories, with a mission of identifying variants, monitoring vaccine response and providing regular updates to the ministry of health regarding the situation in the country. The capacity again is now being directed towards novel and emerging pathogens, and is now being used as a training platform for other countries, including Mauritania.

Dr Francis Amirtharaj discussed the development of sequencing capacity in Abu Dhabi at Sheikh Khalifa Medical City, which now serves as a reference laboratory and WHO collaborating center. Data on SARS-CoV-2 and influenza was presented, including the role for the laboratory as a referral center for surrounding countries. Challenges with establishing robust sample selection criteria, informatics and data management, bioinformatics and analysis, then sharing of the data with appropriate stakeholders in a way that can be easily interpreted. UAE faced similar problems with data storage and analysis, and procured capacity and infrastructure to address this, and are in the process of adding additional pathogen capacity to their systems.

Dr Hanan Al-kindi shared his perspectives from the implementation of genomic surveillance in Oman. Oman is also a regional reference laboratory, and has implemented and operationalized multiple sequencing platforms since establishment in 2007. He discussed how the lab was able to support responses to CCHF in the region, and the role played in supporting HIV surveillance. Challenges again included the sustainability of the licenses for operating the genomics machines, the need for constant improvement and updating of protocols and bioinformatics pipelines to ensure high quality data analysis. Oman is supporting a training-the-trainer program, with the goal of providing a sustainable pipeline of expertise moving forward, in collaboration with international partners in the UK, EU and USA. The capacity of the lab is substantial, but at the height of the COVID-19 pandemic, the lab was not able to keep up with the recommended screening of 5% of samples, which will continue to be a challenge for all surveillance programs in the region.

During the question session, presenters were queried on how CDC performed the genotype-to-phenotype screening, and Dr Davis expanded, explaining that this was done by generating clones and testing their response to antibodies or drugs, or monitoring transmission in culture based models. Concerns were expressed about the

overrepresentation of COVID-19 data in the analyses, and that priority should be given to expanding to pathogens including MERS and other coronaviruses, and that programs should be monitoring for new or novel zoonoses that could be causing the next outbreak.

4.2 Session 2: Opportunities, Challenges and Lessons Learned from Data Sharing

Session 2 was targeted towards data sharing, and how the region can implement best practices to support and expand on existing data platforms to support genomic surveillance, and integration of data from multiple sectors, including the human and veterinary laboratory and surveillance programs.

Dr Ghazi Kayali from HumanLink in Lebanon shared perspectives on data sharing between the human and veterinary interface. Dr Kayali reiterated that data sharing is a critical aspect of disease response, at all stages from prevention, detection, surveillance and response. The importance of sharing high quality data to inform risk assessments and guide public policy is key, but there is also evidence that sharing is not happening in a systematic way at this stage. The barriers to this were classified under technical, motivational, economic, political, legal and ethical, and he emphasized that scientists spend a lot of time in the technical area, which is one of the easiest to tackle. The bigger challenges come at the political, legal and ethical levels, as these cannot be addressed using a single approach, it requires input from multiple sectors to generate a response. Data ownership, punitive responses to sharing, such as seen with SARS-CoV-2 variants, avian influenza in Indonesia and Ebola in West Africa. Adequate communication and coordination between technical bodies and governmental and health bodies can be challenging. He presented a case for legal frameworks to assure data sharing and security, and demonstrated that legal barriers and misconceptions can impede sharing, but emphasized that improved coordination and communication to build trust about what is being done with the data and who is using it, could address a lot of problems in the short term.

The second speaker, Dr Ghazi Mahdi from Iraq shared experiences also at the human and animal interface, responding to outbreaks of avian flu and CCHF in the country. He used these cases to show the time delay between data being reported at the veterinary interface then being shared with the human laboratories. Sampling methodologies were challenging, and a lack of coordination between the laboratories and clinical interface resulted in delays in responses. In spite of the delays and challenges, a response was mounted and surveillance outcomes were reported, but he emphasized that the challenges facing data sharing were multi-factorial, including technical barriers, ethical and legal barriers, that needed to be addressed to ensure a rapid response to outbreaks.

4.3 Session 3: Use of Data and Public Health Policy Impact

The third session addressed the use of data for public health responses and for impacting public health policy. International experts were invited to provide examples and case studies from their perspective of how data sharing impacts policy, research, development and decision making in public health settings.

Dr Leena Inamdar and Dr Babak Afrough from the National Variant Assessment Platform, in the UK Health Services presented data on how data was used in the UK during the COVID-19 pandemic to inform public health decisions. The NVAP program has been specifically set up to help with data sharing, analysis and interpretation, and is working with partners in WHO/EMRO and stakeholders to support strengthening of capacity in regional hubs and national laboratories across the world. One of the goals is to improve national and regional expertise to support cooperation and collaboration for public health interventions, through to developing support for partners to capacity, capability all the way from purchasing equipment to reagents, to training the workforce. Dr. Afrough presented a study on how reporting of the omicron variant was handled in the UK, and the pressure that was put on the health system to respond to the surge in cases. A focus on ensuring appropriate responses to data is measured through risk assessments to make sure that punitive responses don't occur. NVAP is working with 18 countries across multiple regions, supporting training and data analysis, with one of the key benchmarks being how much data is shared by the countries. By assessing the frequency and proportion of genomes shared by country is highly impacted by factors such as capacity, expertise, infrastructure and the availability of samples.

NVAP has established protocols and pipelines to support analyses, and will continue to work actively in the region to support expansion of genomic surveillance beyond COVID-19.

Dr Leith Abu Raddad from the University of Qatar provided a detailed look at how Qatar was able to rapidly establish a surveillance network in response to the COVID-19 pandemic, and how this network now provides critical data for research, development and health interventions. Dr Raddad focused on the close collaboration between the government, health ministries and academic institutions to design a pathogen database that was suitable for both health interventions and research in the longer term. By starting from scratch, the teams were able to build a cross-cutting platform that integrates clinical and research data, allowing for streamlined analysis of samples for projects. He emphasized the benefits of starting with the ground-up approach, and the importance of including all levels in the development of the platform, as this transparency builds trust in the system and encourages use in the longer term. The utility of the platform for case management, vaccine response, infrastructure usage, and epidemiology was demonstrated through case studies. Using the database, the country was able to track the waves of infection, effectiveness of the vaccine response to each wave of variants, demonstrating in a first-of-its-kind study that the vaccine efficacy waned over time against variants at different rates. This was a critical finding that received global attention, and this system has subsequently lead to high quality publications in journals such as Lancet and NEJM.

Dr Ahmed al Barraq from () talked about the implementation of a genomic surveillance program in KSA, and how the database was also established to allow monitoring of disease spread and severity across the country. A sharp increase in sequencing capacity across the country gave unprecedented numbers of samples for assessment, and the health ministry worked with the testing authorities to develop the key data fields that needed to be collected, as well as the key performance indicators that would be monitored to ensure that the data was being shared and used in a timely manner. Teams were established at multiple levels to monitor and assess data, and to generate reports that were shared with policy makers, including virus evolution and vaccine responses, lineages in circulation, severity of disease and more. These reports provided support to public health decision making and for prioritization of responses and research capacity to ensure that the country was agile in response to the pandemic. He emphasized that this expertise has been translated to other pathogens and cohorts, including MERS-CoV, measles and MPOX, as well as metagenomic surveys to track any new pathogens that may be emerging in the country. Dr al Barraq was in agreement that building the database in such a way that it was accessible to multiple sectors would be a key element to streamlining data sharing across borders and sectors.

Dr Shahinaz al Bedri from the National Public Health laboratory in Sudan presented the rapid improvement in laboratory testing and genomics capacity that occurred in response to the COVID-19 pandemic. Sudan is a country which shares borders and entry points with multiple countries that have challenging and endemic pathogens in circulation, as well as diverse climate conditions which are conducive to zoonoses, arboviruses and novel pathogen emergences. She emphasized that climate change has had a clear impact on the disease cycle in Sudan, with changes to the duration and intensity of the rainy season correlating with increased vector-borne disease. Due to its geographical location, Sudan also has regular cycles of migration and displaced citizens in response to conflict, natural disasters which also impact the health system. In spite of this, there is limited investment in public health, and the public health laboratories have to operate under very challenging circumstances. In response to the COVID-19 pandemic, there was initially 20 staff running 20 PCR machines across the entirety of Sudan, which presented a challenge to ensuring that the country was monitored adequately. The country rapidly upscaled training and capacity, so that 180 staff are now trained in PCR, and 100% of the country is covered by molecular testing for COVID-19. A challenge with maintaining and expanding testing is the designation of the health laboratory under the Ministry of Finance rather than health, which can make investment challenging, and leaves the laboratory dependent on international grants, which can also be challenging to receive. Other challenges included a lack of digitization, with all health data still on paper, lack of IT support and infrastructure, lack of expertise in sample collection, data analysis and interpretation. The country now has added Nanopore sequencing capacity to its repertoire and is actively contributing to GISAID, and is expanding genomics capacity through

investment in new platforms, but the sustainability of the program will remain a challenge, as there is a need to convince the government to support national sequencing, rather than the shipping of samples internationally.

5. Group Discussion Sessions

Following the informative plenary sessions, the meeting hosted several group discussions to gather insight from multi-level, multi-sectoral and cross-border contributors into the genomics strategy and operation of a genomics network. The sessions were chaired by international experts, and all suggestions were captured and aggregated for consideration as part of the regional genomics strategy moving forward.

5.1 Session 1: EMR Genomics Surveillance Network - System Visioning Session

5.1.1 Overview

This group session was designed to gain cross-sectoral, national and international perspectives on the vision for the EMR genomics surveillance network, and how the strategy could support tangible outcomes that empower that vision. Key discussion points included understanding how the network would operate, and how member states and stakeholders viewed their contributory roles within that network. Input was sought on how the network could function at all levels, including the laboratory, surveillance and policy level to support public health interventions and decision making, and how the network would be able to tangibly impact public health in the region.

5.1.2 Summary of discussions

The group discussions on this topic produced 51 suggestions on what would be considered key roles for the network, the member states and how the network could function to support the stated goals of a sustainable, regional genomic surveillance network that member states would be inclined to actively contribute. These are summarized in the following sections, and a complete list of the key recommendations can be found in (Appendix 1A).

<u>The EMR Network</u>

The Network as a whole should function to build on existing expertise and capacity in the region to provide genomic support to emerging or re-emerging diseases in the region. It should actively support capacity and expertise building, coordination of logistics, training and data sharing, and advocate for expanded exchange of data and expertise between countries. The network should coordinate the collation, merging and publication of data through digital hubs or dashboards, should coordinate further training in bioinformatics, data analysis and interpretation to enable members to produce useful risk assessments and responses based on genomic data.

The network should further advocate for cross-sectoral collaboration and expansion of genomic support into veterinary and environmental areas, to support a OneHealth based approach to surveillance, ensuring all aspects of the region are being monitored for novel pathogens. The networks should support equitable distribution of expertise and reagents, and support publications, research and development that will enhance regional knowledge and capacity and provide potential revenue streams through collaborative research. The network should constantly liaise and collaborate with international networks to ensure the latest training and best practices are integrated into the regional network, allowing for sustained and improved international cooperation in responding to outbreaks.

On an administrative and coordination level, the network should establish a steering committee comprised of cross-sectoral experts in public health, genomics, surveillance, health policy and advocacy, to provide high-level guidance to the network, and to continually monitor network outputs and key performance indicators ensuring the region is supporting genomic surveillance at the highest level. This should be supported by pillars composed of national and international experts, covering areas such as laboratory, surveillance, communication, data sharing, risk assessments and more, to ensure that the steering committee is constantly supported in their goal of driving the network. The steering committee and pillars should collaborate with stakeholders to produce clear

terms of reference for the network, supporting the establishment of MOU's between member states, institutions and private entities to advocate for continual membership and support of the network in the longer term.

On a functional level, the network should liaise constantly with international experts, and provide meetings, dashboards and communications to member states providing visibility of advances in genomics surveillance, and successes nationally, regionally and internationally in responding to pathogen outbreaks as they occur. They should work with stakeholders to collate, standardize, distribute and continually update operating protocols, best practices, trainings and quality assessment to ensure the network is constantly improving. The network should provide logistical support, advocating for group bargaining and long-term agreements with suppliers to improve the financial sustainability of genomic surveillance in the region, and should ensure equitable access to capacity and expertise across the region in response to emergencies as they occur.

The Member States and Stakeholders

Member states should work with the network and stakeholders to provide support to national and sub-national laboratories, through continual administrative, financial and infrastructural improvements, to establish high-quality laboratories and surveillance expertise that can contribute data to both national public health policy and interventions, and the EMR network, in a timely manner. Sample collection networks, in-country sequencing and data analysis should be supported to ensure timely reporting of results, so they can be considered in risk assessments for communication and distribution when needed.

Support should be given to training courses, covering data sharing and analysis, risk assessments and communication to ensure that the network is updated and apprised of the outcomes of genomic surveillance in country. Member states should support the continual exchange of data and expertise, through twinning initiatives with other states and stakeholders, exchange of experts, and participation in national and international training courses. Member states should also actively participate in collective bargaining agreements and work with ministerial colleagues to facilitate sharing of reagents, samples, experts and data with other members of the network.

Member states should advocate for membership to the network, and work with ministerial authorities to ensure MOUs are equitable for all contributors. They should work with the network to ensure that data produced in countries is risk assessed and communicated in such a way as to be beneficial, and not punitive to the country, to build trust in genomics and to improve responses to pathogens as they emerge. Member states should continually interact with the network to ensure that the latest protocols and procedures for sample collection, laboratory operation and surveillance response and risk assessments are followed.

Member states should provide expertise to the steering committee and key pillars to ensure that national interests are represented in the decision making process for the network as a whole. They should also participate in quality assessment programs, at all levels including laboratory, surveillance and continuing professional development, to ensure that they are producing timely, high-quality data, contributing to successful maintenance of key performance indicators, and are able to support rapid responses to pathogens as they threaten the region.

5.2 Session 2: Opportunities and Challenges in Data Sharing

5.2.1 Overview

This session focused on gathering an understanding from member states on the challenges associated with sub-national, national, regional and international data sharing to support and inform public health interventions and responses. Contributors would asked to discuss their experiences with data sharing at the national and regional level, focusing on specific challenges faced, and what opportunities could arise from improved data sharing across the region. The impact of timely data sharing and its role in disease surveillance was discussed, while recommendations were collected to understand at all levels how the network could facilitate and improve data sharing and integration between multi-sectoral genomic and epidemiological surveillance. The discussion covered shared and unique experiences using existing data sharing agreements and platforms, with a goal of understanding

what would be the optimal support the network could provide to improve and facilitate data sharing moving forward.

5.2.2 Summary of discussions

The group discussions were led by international experts in public health response, with the goal of collating information on the opportunities, and the challenges faced by participants in sharing data at the national and regional level in the past. A discussion on best practices for data sharing was also captured, and the key findings are summarized below. A full list of the key discussion points can be found in (Appendix 1B).

Data Sharing Opportunities

Participants felt that one key opportunity that the network could facilitate would be supporting demonstrable use cases where genomic surveillance has provided a clear public health benefit to a community or country as a whole. The use cases should clearly define how the shared data was used, to improve the understanding of how sharing was beneficial and build trust in genomic surveillance as a tool for public health responses.

This improved awareness and advocacy would encourage multi-sectoral collaboration, and could facilitate improved merging of clinical, laboratory and surveillance data, through digitization or streamlined sharing protocols, improving the capacity to respond to outbreaks as they occur. Assessment of vaccines, diagnostic effectiveness and patient case management are all areas that require extensive data sharing, and improving the awareness of how this data is beneficial will likely facilitate improved data sharing in future.

An opportunity exists now to build on capacity and infrastructure introduced for COVID-19 surveillance, as part of the GISRS network. Regulatory agreements and MOUs for sharing data with international databases have been established through repositories such as GISAID, meaning there is now experience that can be leveraged to expand on those data sharing agreements with other pathogen networks and stakeholders. The tangible benefits of data sharing that came from these programs should be used to influence policy makers to advocate for continued and improved data sharing moving forward.

Data sharing challenges

It was inescapable that genomic data is politically sensitive, not just in the region, but internationally as well. Clinical data needs extremely careful handling, while genomic data needs careful analysis and risk assessment to ensure that punitive responses are limited in response to data shared. Responses to South Africa, China and the United Kingdom sharing novel variants demonstrated the risk that this can present, and will need to be carefully implemented to prevent this happening in future.

A lack of coordination across member states, stakeholders, and even within country at the institute or ministerial level hampers the ability to usefully share and analyze data. This is compounded by a lack of expertise, bioinformatics and data analysis tools that can produce meaningful outcomes from the genomic data, which limits the utility in response to surveillance investigations. This is further impacted when there is insufficient metadata collected at either the patient, sample or laboratory level to provide critical linkages between cases and responses.

A limitation in the availability of trained experts in the workforce accounts for some of these gaps, with a high turnover of staff and a lack of incentivization to remain in national surveillance programs resulting in a drain of experts to private enterprise or out of the country. This needs to be considered and improved in order to facilitate a sustainable genomics network in the long term, either by improved incentivization or improved collaboration with the private sector in the long term.

Best practices in data sharing

The group was given an opportunity to discuss what the best practices would be to embrace these opportunities and to address these challenges through the network. A key element considered by most participants was the development of standard operating procedures that would outline the minimal metadata that needed to be

collected to ensure genomics data was useful, and then to risk assess the data in such a way that the response to outcomes is measured and non-punitive. Improved communication and awareness of the results and what they mean would feed into this platform, to build trust in the protocols that are used.

The development of national and regional data repositories was considered to allow access to the data in a timely manner. Decentralized analysis of the data through the cloud, which would allow member states to retain ownership of the data, but allow the network to include it in larger analyses was considered good practice, with the caveat that data security and ownership needed critical attention before this could be operationalized. Ensuring that member states sharing data had equitable access to repositories is also a key element of building trust in data sharing, as sharing should go both ways.

The establishment of technical working groups or pillars to support coordination and harmonization of data sharing was considered essential to the success of the network. This group would be responsible for supporting data sharing and analysis, updating protocols and risk assessments, auditing data for quality control and continually improving training methods and protocols across the region to continue to facilitate data sharing in response to pathogen outbreaks. This group would also liaise with other essential pillars to ensure that the data shared was used in a responsible manner to produce a tangible public health benefit to the region, and to support cross-sectoral and cross-border training and exchange of personnel to expand national and regional expertise in data sharing pracitses

Clear terms of reference and MOUs for data sharing agreements, defining the rights and responsibilities of the member states and the network, outlining acceptable use and access to the data should also be established, and shared with member states. These can be used to gather ministerial support and advocacy, to build trust in data sharing across the region.

5.3 Session 3: Data Integration - Informing Actionable Outcomes

5.3.1 Overview

While session 2 focused on the mechanisms for supporting improved data sharing, this session focused on how the data shared could be used for actionable and tangible public health outcomes and interventions. The previous plenary session established that while sharing data is essential, it is equally important that the data collected be of sufficient depth and quality to provide actionable information to surveillance and public health teams. Discussion centered on pros and cons of tools that have been used at the national and regional level to support data integration, and what methodologies could be used to address the challenge of merging genomic surveillance data from a diverse range of sources with existing, traditional surveillance mechanisms. Key points for consideration included how the member states, network and region as a whole can improve the frequency and quality of data sharing, and what would be considered the minimal metadata that should be collected to ensure genomic data is useful at a surveillance level, not just for awareness.

5.3.2 Summary of discussions

Discussion in this session was centered around sharing key experiences from data sharing, information management and analysis platforms, to gain understanding of cross-sectoral opinions and preferences for mechanisms to support expansion of data sharing through the network. Session chairs directed discussion to the key topics of tools for data integration, data sharing platforms and practices that had met with success at the national level for data sharing and analysis. A separate discussion about the minimal data requirements that should be met for data sharing was also driven by the member states. Below is a summary of the findings, while a complete list of results can be found in (Appendix 3).

<u>Tools for Data Integration and Data Sharing Platforms</u>

A shared theme across the groups was the need to merge existing national databases, whether they be digital or paper-based into harmonized data management systems. The examples of DHIS2 implementation in member

states were generally positive, with a push for moving from paper or excel-based systems into a more clinically useful database system. The idea of a regional database was mooted, but the challenges associated with housing data from multiple countries in hubs is significant, and the option of decentralized data storage with centralized analysis as a hybrid model, similar to that supported by Rockefeller in Brazil, was considered a strong alternative.

Expansion of data analysis and storage tools from the human sphere into environmental, veterinary and social databases was considered a key to successful pathogen surveillance, as this would expand analysis beyond purely laboratory based results. Standard operating procedures and strong terms of reference for how this data can be used and analyzed would be critical for the success of this tool. The participants emphasized challenges in merging these systems, as even human and veterinary databases gather significantly different data, and have different information security components, which can result in a lengthy process for either sector to access or use data from the other.

Digitization of data collection was a key discussion point, to streamline data sharing and analysis, reduce errors in transcription and improve data-driven outcomes. Training for field and laboratory staff in data entry, as well as improved IT support for digital systems, paired with routine auditing and monitoring of data quality and timeliness of data entry were considered as critical improvements to support regional health outcomes. Participants discussed the use cases for DHS1/2, IDSR and LIMS platforms, looking at the benefits and challenges associated with implementing digital surveillance and shifting practice from paper.

Participants also discussed the benefits of biohubs for cross-sectoral sample sharing and storage, as a potential mechanism to facilitate improved collaboration and integration with other platforms as new tools become available. Linkage of sample data with storage data would be critical to this, and legal agreements and MOU to protect access and usage of the samples would be challenging.

Tools to support data analysis and integration

A key component of establishing data integration was ensuring that minimal metadata collection was encouraged at all levels of clinical and laboratory practice. This included pairing clinical data with sample collection, transport and referral, laboratory, bioinformatics and analysis protocols to ensure a full story can be completed when a case is being investigated. Training was again a key element of this, ensuring that detailed operating procedures and protocols were established and used at all levels of sample collection and analysis.

In the previous discussion, participants advocated for digitization of data, and following on from this proposed that the member states at all levels should be involved in the design and development of databases, to ensure that all systems can integrate with regional data sharing and analysis platforms. In this way, all sectors could have access to data in a timely manner for risk assessments and case management, but would require extensive development, investment and coordination to achieve. A key element of the success of such a sharing platform would be working with the private sector to ensure that data from all sources is available for deposit, and establishing ministerial and MOU support for such practices would require advocacy at all levels.

Continued bioinformatics training in open-source platforms will expand the available human resources and expertise available for complex epidemiological analysis and risk assessments using genomic data. Tools such as EPI2ME and CLC can be intuitive, but continuing to build skill in coding in languages such as Python, Java and R, as well as data visualization packages such as Nextstrain, will allow more detailed analyses and clearer understanding of results in future.

Monitoring and evaluation of data sharing and analysis, through quality assurance programs will help with developing a sustainable genomics network, and build trust in the data. Policy at department, institute and national level to support frequent and timely sharing of data, completion of training programs in everything from sample collection to bioinformatics and data analysis, integration of genomics with rapid support teams were all considered as performance metrics by participants.

Potential metadata prioritization

Priority	Secondary
Clinical ID	Vaccine status
Laboratory ID	Climate data
Geographical details	Social data
Collection and processing dates	
Host/species data	
Symptoms	
Gender and age	

** this list will be reviewed and expanded before inclusion in protocols.*

5.4 Session 4: Design and Development of the Genomic Surveillance Network

5.4.1 Overview

The initial sessions in the group discussions focused on strategic and high-level objectives for the network, gathering stakeholder and member state experiences and information on issues surrounding coordination, logistics, visibility, data sharing and analysis, and how this could be integrated with existing surveillance systems. This session focused on the tangible design and development of the surveillance network, and what the stakeholders would consider to be the optimal functions and outputs of such a network. Participants were asked to outline what they would consider use-cases for support by the network, and whether mechanisms such as a "hub-and-spoke" laboratory model, with national and sub-national laboratories supporting regional hubs to produce actionable data. Elements of monitoring and evaluation were investigated, including how training, assessment and continuing professional development can be optimized to ensure a sustainable network and workforce, and how standardization of practices could help or hinder the network operational capacity. A final session of discussion was then held to establish what the stakeholders and member states considered as the main areas of support needed from the network to allow for high-level advocacy for member states to join and sustain the network in the long term.

5.4.2 Summary of discussions

Session moderators in this session were tasked with gathering feedback in three primary areas. Optimal use cases and how the network should be designed to support them, what policies and protocols would allow accurate and sustainable monitoring and evaluation of outputs, and what areas needed tangible support to ensure the network is a success. Below is a summary of these discussions, with a complete list of findings added in (Appendix 1D).

Network Design, Use cases and key support recommendation

Initial discussions in this session focused on the benefits and challenges associated with the proposed "hub-and-spoke" surveillance model. Previous sessions had already defined that sample and data sharing across borders is challenging, which would limit the benefits of the hubs for primary response to emergencies. These challenges need addressing, specifically logistical challenges associated with high-risk sample transport, cold-chain issues, data sharing and sample sharing agreements at the national and international level.

However, there have been clear examples of this model working in the region and internationally. UAE provides support for sequencing of SARS-CoV-2 and influenza samples, Egypt provides support for avian influenza genomics for the region. Internationally, the East Africa Rift Valley network provides support for decision making and prediction of pathogen spread, the COVID-19 Genomics Consortium in the UK (COG-UK) linked academic, public

health and industry partners to provide saturation sequencing coverage for the United Kingdom, and the European FMD network links human and veterinary data to support responses to zoonoses as they emerge.

While these networks are success stories, participants were in agreement that in-country sequencing provides the most rapid turnaround in data production and analysis to support public health decisions. 21/22 countries in the region have sequencing capacity, so expanding this into other pathogens, then advocating for data sharing and analysis through shared cloud-based platforms was considered an optimal use-case. This would need continued support in training, capacity and logistics, with the hubs serving as training and quality assurance platforms, as well as surge capacity during emergencies. Legal frameworks, MOU and clear terms of reference would be needed for either of these models, and will require assessment before inclusion in the regional strategy.

The optimal use cases for the network were part of the next discussion, with contributors asked to define what situations the network would be best placed to address. Cross-border epidemics and pandemic response to decrease mortality and morbidity over a wide geographical area was the overriding goal, but coordinating multi-sectoral responses to monitor migration, livestock movement, social and natural disruptions that impact health scenarios was considered key to the functioning of the network. Provision of the regional surveillance network, collating and visualizing data from multiple sources to improve statistical power of surveillance analyses, including pathogen distribution through phylogenetics, but incorporating data from climate change and environmental factors to provide a higher level assessment of situations. Coordination remained a key recommendation; logistics and purchasing power, collation, assessment, distribution and updating of protocols at all levels, unification and harmonization of training protocols, improved transparency of results and resources in the region, and harmonization of multi-sectoral laboratory responses to allow surge capacity by sharing resources across human and veterinary laboratories were all considered key provisions of the network.

Tangibly, the network was encouraged to support the development of roadmaps for managing the network, including equitable allocation of budgets and resources, establishment of steering committees and technical working group pillars, to provide opacity on how the network will function. The protocols established by these committees should be provided to member states to provide advocacy at the decision maker level, and to support implementation of MOUs to operationalize as soon as possible. Central monitoring and publication of regional capacities and competencies, data sharing and disease situations through digital platforms, to improve understanding of the existing situation, and to monitor improvements over time through a digital portal was mooted. This portal should also support data sharing, policies and data analysis, housing of the latest operating protocols and training materials and feedback from meetings and workshops. The network was also encouraged to liaise and build support for linking academic and private capacity to support expanded research, development and strategies, to start building expertise early, allowing for a skilled network to be maintained long-term.

Monitoring and Evaluation

The implementation of quality frameworks to support the functional assessment of the network was one of the recommendations supported by the group discussion. International Health Regulations (IHR) and International Standards Organization (ISO) frameworks exist that provide guidance and assessment of laboratory, surveillance, IT, bioinformatics, data sharing and security, cloud-based data infrastructure and more. Driving for recognition or accreditation through these systems would ensure international recognition of the data produced in the regional and national laboratories.

Clear terms of reference, roles and responsibilities, supported by defined key performance indicators, monitored at the national, pillar, and steering committee level was recommended, with benchmarks suggested for competency, training, sample collection and sharing, risk assessments, responses, outbreak prevention, and feedback from stakeholders and policy makers on the effectiveness of the network. Simulation and field exercises, either benchtop or actual, were supported for monitoring the agility of the network to respond to emergencies as they occurred.

Continual assessment of laboratory and surveillance performance, training and continual professional development, in collaboration with national and international training bodies was another suggestion, with portfolio based assessment, similar to that required in the UK, USA and EU mooted as mechanisms to support professional development and sustainability of the workforce in future.

Electronic platforms, including dashboards that collate sample and response data, as well as provide a visual assessment of KPI metrics were recommended, to be hosted and overseen by the network and leading to accountability of the members in the network. A suggestion that proficiency testing at the EQA level should be expanded from solely WHO protocols and programs into commercial EQA platforms such as QCMD, to improve global accountability and compliance was also suggested at the national level.

6. **Key outcomes and next steps**

The outcomes of these group discussions demonstrate that participants are encouraged by the concept of the network, but have clear expectations of what the network should provide, and how member states should engage with it to ensure that tangible outcomes are produced. Coordination and harmonization of the network, improvements in data sharing and visibility, awareness of capacity and improved monitoring and evaluation, and support for member states at the policy level are key recommendations supported across all sessions.

The findings are being collated and discussed at the regional level, and WHO/EMRO will seek to incorporate them into the regional strategy, in line with the recommendations of the Global Genomics Surveillance strategy, to ensure that Member state interests are taken into account in the implementation of the strategy. A draft of the regional strategy will be prepared and will be discussed at a meeting in mid-late 2023.

The organizers would like to thank everybody for their active participation in the meeting, and to thank all speakers, session chairs, rapporteurs and the administrative team, without whom the meeting would not have been possible.

Appendix 1a. What is the vision for EMR Genomics Surveillance Strategy Network for pathogens with pandemic and epidemic potential?

Role of Network	Role of Member States	Functionality
Facilitate member state cooperation and engagement across EMR to support and sustain genomic surveillance producing meaningful integration of genomics into existing surveillance architecture and research frameworks.	Provide domestic resource mobilization for national/sub-national genomics capacity, with continuous monitoring and evaluation of laboratory performance, staff training and competency, quality assurance.	Establish technical working groups to support harmonization of operating protocols supporting best cross-disciplinary sampling practices, laboratory practices, risk assessment and monitoring and evaluation frameworks with key performance indicators to sustain and improve external quality assurance enrolment and success.
Establishing a technical working group, including a broad range of stakeholders, to provide linkage between member states and international stakeholders to facilitate sharing of information and data to assure equitable and rapid distribution of resources.	Establishing technical working groups to facilitate integration of risk assessments, data sharing, pathogen hazards and early warning capacity, into existing surveillance networks.	Implement regional databases containing country-level standard operating procedures for laboratory and surveillance, supporting increased awareness standardization of operations, and improve logistical linkage and buying power for the region.
Promote and advocate for active and equitable participation of member states in international OneHealth, food security and public health programs.	Producing complete, timely and high-quality datasets suitable for submission to national, regional or international databases.	Establish working groups to support best practices for sharing data with policy makers and stakeholders in a clear and concise manner to support public health decision making.
Establish the TOR for the operation of the EMR genomic surveillance network, for distribution to ministerial appointees in member states.	Ensure that data is incorporated into risk assessment and decision-making processes by establishing national guidelines to support evidence-based policy development.	Develop and implement multi-sectoral and regional data sharing agreements and digital platforms to support sharing and integration of genomic surveillance data with existing surveillance mechanisms to support public health outcomes in near real-time, and to improve advocacy for cross-border data sharing by demonstrating outcomes.
Coordinate, harmonize and update operational protocols and policies through regional databases, enhancing the understanding of national capacity across the region, and promote accessibility to reagents and equipment through regional procurement with suppliers.	Ensure transparency of operational processes and engage with other members of the network, to ensure adherence to regional and international standards.	Develop research prioritization guidelines to support regional programs, grant submissions and publications to improve regional understanding of emerging pathogens.
Develop and provide guidelines and databases for standard operating procedures, including updating and maintaining laboratory protocols, minimal data collection recommendations, interoperability of clinical and genomic data, sharing and accessibility and quality management.	Support multi-stakeholder collaboration (academia/research institutions, government institutions, NGOs, private institutions, military institutions, etc) to leverage existing networks using a OneHealth approach to support appropriate genomic surveillance.	Develop and deliver regular multi-sectoral training programs for laboratory, bioinformatics and surveillance to build a skilled workforce with national and regional capacity to respond to emerging diseases.
Support the monitoring and evaluation of member state competency, providing support for training and continuing professional development for laboratory, bioinformatics and surveillance programs to promote the sustainability of networks by retaining staff.	Establish formalized agreements (MOU, TOR, other mechanism) and provide advocacy to ministerial and national levels to assure collaboration, engagement and commitment to the network.	Develop and MOU or TOR clearly outlining the functionality of the network at national and regional level to support ministerial approval of participation in the network.
Provide logistical support for transfer of samples, reagents, reference materials, data sharing and analysis, and enrollment in external quality assessment schemes.	Establish technical working groups with routine, documented meetings and outcomes to support genomics and surveillance in the country.	
	Advocate for the development of mechanisms at the government level to support the exchange of experts and staff to develop skills in both labs, surveillance and leadership roles.	

Appendix 1b. What are the opportunities and challenges in sharing data?

Opportunities	Challenges	Data sharing practices
Build trust in data sharing by establishing demonstrable use cases with clear public health benefits, expanded training, awareness and understanding of how data will be used.	Political sensitivity of data has implications on the economy, trade and travel, reducing the will to share data for fear of punitive responses.	Develop standard operating procedures outlining minimal metadata requirements to be linked to genomic data to ensure actionable genomic surveillance outcomes.
Improved group bargaining power for bioinformatics licenses as well as lab consumables.	Lack of coordination of data sharing across sectors at national and regional levels, including lack of protocols for data sharing, standardization of minimal metadata requirements and data governance.	Develop standard operating procedures to support risk assessments prior to sharing data with international databases, to minimize the risk of punitive measures or negative public response to data shared and to support incorporation of genomic surveillance data into standard surveillance mechanisms, such as sitreps.
Merging of laboratory data and clinical metadata through LIS/LIMS to produce surveillance outcomes, dashboards and online resources for data sharing across multiple sectors.	Lack of incentivization to share data, lack of guarantees to ensure appropriate attribution of credit for outcomes (research, projects, grants) coming from shared data, or lack of compensation for negative outcomes due to sharing data (i.e loss of flocks etc)	Develop national and regional data repositories linked to national/regional data centers supporting dashboards and alert networks for notifiable diseases or novel pathogens or variants to support broader dissemination of data across a region.
Encourage multi-sectoral collaboration to support integration of genomics surveillance with traditional surveillance networks.	Bioinformatics and analysis tools are technically challenging and changing constantly, so there's a need for maintenance and updates of protocols and constant and improved training methods.	Countries can retain ownership of data and use decentralized analysis platforms through the cloud.
Improved ability using genomic surveillance to respond to outbreaks to prevent future pandemics.	Insufficient metadata limits the utility of sequencing and prevents meaningful surveillance outcomes, potentially due to lack of awareness of the minimal data requirements to generate a meaningful genomic surveillance intervention.	Ensure equitable sharing and access to the data to the partners using the network and assurance that credit is given to the appropriate contributors.
Improved awareness between stakeholders, surveillance and media or social media outlets on the importance of genomics.	Limitations in trained workforces in some countries, with high turnover of staff resulting in loss of skills prevents sustainable genomics.	Develop protocols for coordination of data-sharing, including Curation and quality control of data at a national level prior to submission to regional or international database.
Capacity for the assessment of vaccines, diagnostics, interventions and case management, and future innovation using genomic data.	Lack of diagnostics to identify appropriate samples for sequencing can lead to overspend or poor data quality.	Establish technical working groups to support a data sharing platform in the region, supporting routine meetings to discuss shared data, audits and quality control, improvements to technology and training protocols to streamline data sharing in the region.
Capitalizes on existing infrastructure and workforce for viral sequencing established through influenza sentinel surveillance and during the COVID-19 pandemic, including existing regulatory agreements at national level that can be leveraged at a regional level.		TORs and data sharing agreements defining the roles and responsibilities of member states and outlining acceptable use for shared data provided to ministers to build support and advocacy for data sharing across the region.
Leverage experience from national coordinating bodies to support establishment and coordination of OneHealth interventions and programs.		Support for training and exchange of personnel between countries and sectors to improve understanding of data sharing practices and build trust for multisectoral data sharing.
Ability to influence policy makers in a timely manner using evidence-based outcomes generated from regional data sharing.		.

Appendix 1c. How will data integration lead to actionable outcomes?

Tools for data integration	Data sharing platforms	Data sharing practices
Merging new and integrated national electronic database (multi-sectoral, LMIS/DHIS) supporting data storage and reporting of results, potentially linking to a regional database (OneHealth) that are interoperable with existing surveillance databases (support automation).	Apps for collection of at-home data from rapid tests.	Develop or establish an appropriate sample collection, referral system, including logistical issues (local manufacturing of packaging and transport).
Integration with environmental and social databases with pathogen specific databases.	IDSR, DHIS1/2, LIMS and metadata.	Testing at different levels (animal, clinical, academic and private) providing data/samples and analysis taking advantage of existing capacity.
Tools for data analysis and training to use them.	Quality assurance platform and data security and confidentiality agreements (Sudan, defined levels of confidentiality for data) within programs	Use alternative methods that can support the genomic data for known pathogens (snp typing etc).
Standardized case definitions and guidelines across the region to support appropriate data collection.	Biobanks/hubs for sample/data integration	Logistical/MTA support for transfer of samples (multi-pathogen) between countries/hubs.
Pathogen specific guidelines on how many samples to collect for useful surveillance outcomes.	IATA certification and training for sample transport.	Designation of specific labs for pathogen sequencing (hub level), Human resources, training of trainer to support sustainable workforce.
Auditing, monitoring and evaluation of data quality and timeliness	Online Data entry training platforms.	Training for sample collection from multiple sites, species/wildlife, environment, food (multisectoral rapid response teams, agreements between ministries).
Standardized SOP for data sharing, integration, analysis and dissemination.	SEHA application: testing linked to national ID number and deposited in database	Data shared with ministerial advocates and decision makers to support health policy decisions.
High quality data that is fit for purpose of genomic surveillance (e.g CCHF for human/animal will have different data requirements)	IRIS programme, tagging animals after vaccination to includes metadata for the animals	Define how we build on private sector work post pandemic to ensure sustainability in the public sector, teams included in access and development of the database.
Digitalization of data, trained IT personnel to support networks/databases, counters to understand access and usage of the databases.	Two separate systems for animal and human data which do not communicate with one another	Policy at the country level to govern deposition of such data in the public sector which should be not for profit
Training for field and lab staff and clear definition of metadata required, templates for data collection (mandatory, optional), and for which data to be uploaded to national or international databases.	Integration of platforms requires funding and expertise, Elongated process for data sharing in animal sector compared to COVID	Integrated of electronic systems rather than paper-based systems to reduce transcription errors, for frequent, timely data availability and access.

Appendix 1d. What is the optimal design & development of Genomics Surveillance Strategy Network for pathogens with pandemic and epidemic potential?

Use cases and network design	Monitoring and Evaluation	Areas of Support
Sample sharing (logistical issues moving across borders to the hubs) difficult to find couriers to move high risk pathogenic samples of known or unknown etiology.	Cross-border epidemic, outbreak, pandemic responses that decrease mortality and morbidity over a wide geographic area, including monitoring livestock trade (legal and illegal), migration that spreads disease.	Management of the network, allocation of budget, roadmaps for deliverables with timeframes
In-country capacity improves speed of results.	Regional surveillance, provision of improved statistical information (increased sampling power) about pathogen distribution and phylogenetics for surveillance, impact of climate change and environmental factors on cross-border disease spread.	Training support and harmonization for lab, bioinformatics, surveillance, data analysis and visualization, sample collection.
21/23 countries have laboratory sequencing capacity from Covid-19, build on this capacity and feed information/data into the network, use the hubs as bioinformatics and training support.	Sharing of SOPs, case definitions, and unified policies for testing (molecular, serology or sequencing) and risk assessment that feedback of results and testing outcomes to primary sources	Advocacy for decision maker support by demonstrating functionality of the network.
Support successful implementation of the network by reviewing existing networks:	Sharing of reagents, training, logistics (transport of samples), to support integrated joint response teams covering lab, health surveillance and veterinary experience.	Understanding competencies of the member states to support improvements in communication to support development into equitable national systems.
UAE sequencing of SARS-CoV-2 and influenza for emergency countries.	Enhancing coordination between member states to improve transparency of results and resources in the region to improve sharing and equitable allocation of resources between sectors.	Improved understanding and feedback on the value of the data in both directions back to primary sources as well as to international partners to sustain the network long term.
Influenza network sharing data with global network, enrolled in EQA programs, coordinated training and competency, all supporting public health responses. FMD network across Europe for sharing data and informing responses.	Veterinary laboratories as surge capacity for testing in both directions (human to animal, animal to human, cross-utilisation) while provide genomic surveillance for veterinary pathogens using human infrastructure.	Build trust between the scientific community and the broader public through improved communication and outreach.
East Africa RVF network for decision making and prediction of pathogen spread.	Applying the IHR2005 or latest IHR framework across borders.	Build an electronic portal supporting data sharing, best operating practises, guidelines, integrated SOPs, learning modules, training materials, awareness materials, virtual workshops and meetings (bioinformatics and data analysis), in-person training for labs, decision support tools, modelling tools to support policy decisions, forecasting.
Potential for hybrid model with sequencing in country (though there are challenges support funding, workforce, reagents, logistics) with SOP, training, bioinformatic, data analysis and EQA support from hubs.	Aim for ISO accreditation of regional hub laboratories (ISO15189 or 17125)	Involve academia in training, developing skills base, ensuring the there is a departmental strategy is considered when nominating people for training courses.
Annual or bi-annual conferences to support sharing of data and expertise.	Key performance indicators (competency, samples tested, quality results, number of outbreaks detected and prevented, feedback from decision makers, ministries and communities on how this has benefited the countries)	Simulation exercises, scenario testing, benchtop exercises, field exercises
Legal framework supporting the operation of the network, twinning support between institutions and countries.	Proficiency testing materials shared from hubs to regional labs, including best auditing practices.	Roles and responsibilities clearly defined for monitoring and evaluation, including defining a quality committee to establish who will do assessments and evaluations.