



NATIONAL GENOMIC SURVEILLANCE STRATEGY FOR PATHOGENS OF PANDEMIC POTENTIAL

2024-2028

SEPTEMBER 2024



**World Health
Organization**

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ACKNOWLEDGEMENTS

The National Genomic Surveillance Strategy has seen the light of day because of the strategic effort of the Ministry of Health (MoH), its Agencies, Developing Partners, and all other relevant stakeholders.

The Ministry of Health gratefully acknowledges the current leadership thus the Minister for Health, Hon. Dr. Bernard Okoe Boye and his two Deputies Hon. Alexander Akwasi Acquah and Hon. Adelaide Ntim and the Chief Director, Alhaji Hafiz Adam under whose leadership the National Genomic Surveillance Strategy was developed.

The Ministry of Health also appreciates the immediate past leadership Hon. Kwaku Agyeman-Manu (MP) and his two (2) deputies: Tina Mensa (MP), Alhaji Mahama Asei Seini (MP) for supporting the process.

We further wish to appreciate the Health Sector Working Group under whose supervision and guidance this document was developed.

Our deepest gratitude to the Director for Policy, Planning, Monitoring, and Evaluation (PPMED) and to all members of the Technical Working Group for their expertise and technical guidance in the development of this all-important prioritized national document for Ghana.

Our special thanks also go to other key stakeholders including Ministry of Food and Agriculture, Ministry of Environment Science Technology and Innovation, Research and Academic Institutions, Private Health Sector Actors, and Individuals who have spent time proofreading and providing vital information towards the enrichment of this document.

Special thanks go to the World Health Organization (WHO), for financially and technically supporting the development of the strategy.

(Kindly refer to the list of stakeholders and their designations under appendix 5. Pg. 53).



FOREWORD

Genomic surveillance plays a crucial role in responding to infectious diseases. By analysing the genomes of pathogens, scientists can gain insights into their origins, virulence, transmission patterns, and potential for drug resistance. This information is valuable for developing effective prevention strategies, diagnostic tools, and targeted treatments. An effective genomic sequencing ecosystem is essential for ensuring a responsive and quality driven approach to any future pandemic.

This technology has been critical in the else while COVID-19 response and has shown that health systems need genomic surveillance as an early warning tool for detecting and characterising the epidemics and pandemics potential if emerging pathogens. Hence, a call by the World Health Organization for member states to strengthen and make significant investments in pathogen genomic surveillance.

Consequently, the Ministry of Health (MoH), in collaboration with its key stakeholders including Academia and Development Partners has developed this prioritized National Pathogens Genomic Surveillance Strategy to provide strategic direction. The five (5) years National Pathogen Genomic Surveillance Strategy (2024-2028) has five (5) key strategic objectives with carefully selected interventions all geared towards an improved quality public health system for pathogen genomic surveillance.

Objective 1: Improve access to infrastructure and logistics for pathogen genomic surveillance.

Objective 2: Improve sample management, data capture, storage, analysis, use, and management.

Objective 3: Strengthen human resource capacity for pathogen genomic surveillance.

Objective 4: Strengthen innovation and research in genomics.

Objective 5: Strengthen governance in genomic surveillance.

These objectives are hinged on collaboration, country ownership, ethical conduct, equity, sustainability, and transparency as the guiding principles which draw inspiration from several global, regional, and sub-regional compacts and policy frameworks that support the broader health sector vision of ensuring a healthy population for national development.

Therefore, as the Minister responsible for Health, it is my desire that all stakeholders collaborate effectively to support the implementation of this all-important national document as we seek to double our efforts to strengthen resilience to new and emerging pathogens. The five (5) year (2024-2028) strategy is expected to be implemented by all stakeholders *“in the spirit of One Health”* as enshrined under the implementation arrangement in a coordinated manner.



HON. DR. BERNARD OKOE BOYE
MINISTER FOR HEALTH



ACRONYMS

AfCDC	Africa Centres for Disease Control and Prevention
AMR	Antimicrobial Resistance
AU	African Union
CDC	US Centers for Disease Control and Prevention
CHAG	Christian Health Association of Ghana
CHPS	Community-based Health Planning and Services
CMA	Common Management Arrangement
COVID-19	Coronavirus Disease-19
CSOs	Civil Society Organizations
DNA	Deoxyribonucleic Acid
EIDSRs	Electronic Integrated Disease Surveillance and Response System
EMA-I	Event Mobile Application-I
ESBL	Extended Spectrum Beta-Lactamase Bacteria
ESKAPE	Enterococcus, faecium, Staphylococcus aureus, Klebsiella Pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter species
FAO	Food and Agriculture Organization
FBOs	Faith-Based Organizations
FDAG	Food and Drugs Authority Ghana
GCPS	Ghana College of Physician and Surgeons
GHS	Ghana Health Service
GHSI	Global Health Security Index
GIDL	Genomic and Infectious Disease Laboratory
GISAID	Global Initiative on Sharing All Influenza Data
GLASS	Global Antimicrobial Resistance and Use Surveillance System
GMO	Genetically Modified Organism
GSA	Ghana Standards Authority
HeFRA	Health Facility Regulatory Authority
HIV	Human Immunodeficiency Virus
IALC	Inter-Agency Leadership Committee
IHR	International Health Regulations (2005)



KCCR	Kumasi Centre for Collaborative Research in Tropical medicine
KNUST	Kwame Nkrumah University of Science and Technology
M&E	Monitoring and Evaluation
MDAs	Ministries, Departments and Agencies
MES	Monitoring and Evaluation System
MMDAs	Metropolitan Municipal and District Assemblies
MoF	Ministry of Finance
MoH	Ministry of Health
MoI	Ministry of Information
MRSA	Methicillin-Resistant Staphylococcus Aureus
NAATs	Nucleic Acid Amplification Tests
NCCE	National Commission of Civic Education
NDPC	National Development Planning Commission
NGS	Next Generation Sequencing
NHIA	National Health Insurance Authority
NHIS	National Health Insurance Scheme
NHP	National Health Policy
NMIMR	Noguchi Memorial Institute for Medical Research
NPHRL	National Public Health and Reference Laboratory
NTP	National Tuberculosis Control Programme
PCR	Polymerase Chain Reaction
PHC	Primary Health Care
PPME	Policy Planning, Monitoring and Evaluation
RDT	Rapid Diagnostic Test
RT-PCR	Reverse Transcription Polymerase Chain Reaction
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SDGs	Sustainable Development Goals
SILAB	International System Laboratory
SORMAS	Surveillance Outbreak Response Management and Analysis System
TB	Tuberculosis
TH	Teaching Hospital
UHAS	University of Health and Allied Sciences
UHC	Universal Health Coverage
UNICEF	United Nations Children's Fund



VSD	Veterinary Services Directorate
WACCBIP	West African Centre for Cell Biology of Infectious Pathogens
WACML	West African College of Medical Laboratory Scientists
WAHO	West African Health Organisation
WHA	World Health Assembly
WHO	World Health Organisation
WOAH	World Organization of Animal Health



GLOSSARY

ACE 2 Receptor

Angiotensin-Converting Enzyme (ACE) 2, is an enzyme that generates small proteins by cutting up the larger protein angiotensinogen that goes on to regulate functions in the cell. Using the spike-like protein on its surface, the ACE 2 receptor, the SARS-CoV-2 virus binds to ACE 2 receptor like a key being inserted into a lock, prior to entry and infection of cells. Hence, ACE 2 receptor acts as a cellular doorway receptor for the SARS-CoV-2 virus.

Clade

Clade is a term for a group of organisms that all originate from a common ancestor and is widely used in biology. In virology, a clade describes groups of similar viruses based on their genetic sequences, and evolutionary changes in those viruses can also be tracked using phylogeny. Generally, the genetic variations of a virus family are grouped into clades, which can also be called subtypes, genotypes, or groups.

Bioinformatics

Bioinformatics is a field of computational science that has to do with the analysis of sequences of biological molecules. It is a sub-discipline of biology and computer science concerned with the acquisition, storage, analysis, and dissemination of biological data, most often DNA and amino acid sequences. Bioinformatics uses computer programs for a variety of applications, including determining gene and protein functions, establishing evolutionary relationships, and predicting the three-dimensional shapes of proteins.

Epidemiology

Epidemiology is the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the control of health problems. This method involves scientific, systematic, and data-driven analysis and interpretation of the frequency and patterns of health-related states and events that are not limited to diseases. Epidemiology is often described as the basic science of public health and relies on evidence-based practice to undertake direct, prompt and effective public health control and prevention measures.

Genome

A genome is an organism's complete set of DNA, including all of its genes. Each genome contains all the information needed to build and maintain that organism.

Genetic Epidemiology

Genetic epidemiology is a discipline that seeks to understand how genetic factors interact with the environment and contribute to health and diseases in families and populations.



Genomic Epidemiology

Is the use of pathogen genomic data to determine the distribution and spread of an infectious disease in a specific population and the use of information to control the health problem.

Genomic DNA Sequencing

Genomic DNA sequencing is a laboratory technique that is used to determine the entire genetic makeup (or specific genic region) of a specific organism. DNA sequences from specimens can be compared to help scientists track the spread of a virus, how it is evolving and how those changes may affect public health.

Genomic Surveillance

Genomic Surveillance is the process of constantly monitoring pathogens and analyzing their genomic similarities and differences.

Medical Tourism

Is the process of traveling outside the country of residence for the purpose of receiving medical care.

Multiplexing

This allows for many samples to be pooled and sequenced simultaneously during a single run on a next generation sequencing (NGS) platform. Sample multiplexing is particularly when targeting specific genomic regions or working with smaller genomes.

Point Mutation

A mutation is a single change in a virus's genome (genetic code). Mutations happen frequently, but only sometimes change the characteristics of the virus.

Pathogen

A pathogen is an organism that causes disease.

Surveillance

Surveillance involves the ongoing, systematic collection, identification, collation, analysis, interpretation, and dissemination of health-related data to inform public health action.

Pathogen surveillance

Pathogen surveillance involves the ongoing, systematic collection, identification, collation, analysis, interpretation, and dissemination of pathogen data to inform public health action.





01 CHAPTER ONE

1.0 INTRODUCTION

Genomics is the study of a complete set of genes (the genome) of organisms, of the way genes work, interact with each other and with the environment. Genomic Surveillance is the process of constantly monitoring pathogens and analyzing their genomic similarities and differences (WHO-2022). The growing understanding of genomic sequencing information and rapid availability of pathogen sequences makes genomic sequencing vital for disease surveillance. The COVID-19 pandemic has also highlighted the critical role of pathogen sequencing in making informed public health decision. Genomic surveillance is transforming public health action by providing a deeper understanding of pathogens, their evolution, transmission, and circulation.

It is an aspect of public health surveillance that involves systematic collection, identification, collation, analysis, interpretation, and dissemination of genomic data of pathogens to inform public health action. Genomic surveillance plays a crucial role in monitoring and responding to infectious pathogens, including viruses and bacteria. By analyzing the genetic material of pathogens, scientists can gain insights into their origins, transmission patterns, evolution, virulence, and potential for drug resistance. In the case of emerging and re-emerging infectious diseases or outbreaks, such as the COVID-19 pandemic, genomic surveillance becomes even more critical for understanding disease trends.

Genomic surveillance enables the identification of new variants or strains of pathogens, that may have different characteristics or pose a greater risk to public health. This information is valuable for developing effective public health interventions such as vaccine development, design of diagnostic tools, and targeted treatments. It also helps with monitoring therapeutic efficacy and tracking the evolution of variants (WHO-AFRO, 2022). There are disparities in genomic surveillance capabilities between high and low-middle-income countries that is impeding effective responses to outbreaks and pandemics. Global disparities in the availability, quality, and use of genetic technologies, genomic research as well as provision of genomic services exist for several reasons. These include a lack of financial resources and a lack of health services and infrastructure. Genome-related technologies can contribute to improving global health equity. To do so, the genomic health divide must be addressed and ultimately bridged through equitable economic investment, clinical/basic science research, and the provision and use of genomic services and technologies globally. The exchange



of existing information, expertise, and technologies between high-income and low-income countries can speed up this process. Reliable and accessible laboratory services that produce quality-assured results in a timely manner is critical for any country's surveillance capacity and early warning function. Recent developments in genomic sequencing and bioinformatics have resulted in some countries establishing and strengthening their capacities and capabilities.

A World Health Organization report indicated that though some countries have made significant improvements in genomic sequencing, others are far behind (WHO, 2022). To implement an effective genomics surveillance system, countries need to invest in laboratory infrastructure, establish collaborations with regional and international partners, and build local capacity in genomic sequencing and analysis. This includes training scientists and healthcare professionals, developing quality assurance measures, and ensuring responsible sharing of genetic data. To help address these gaps the World Health Assembly in 2021, called on its member states to strengthen genomic surveillance in emergency preparedness and response. The idea was to support countries to expand their capacities and harmonize their efforts towards developing robust national genomic surveillance systems (WHO, 2022).

There is enough evidence that genomics has the potential to reshape clinical practice and fundamentally change the way we prevent, diagnose, treat, and monitor illness, providing the opportunity to have more precise and tailored treatments. The ability of the health sector to respond to this change is dependent on developing and strengthening Ghana's capacity, capability, and infrastructure needed to support the integration of genomic technology into the national health system, particularly regarding clinical utility, workforce, education, data security, and sharing quality research. To do this, the health benefits of genomic knowledge and technology need to be harnessed and incorporated within the Ghana health system in the most effective possible way.

As a result, the Ghana Ministry of Health seeks to leverage the advances in genomics to develop a national-level strategic document that recognizes the potential of using genomics to improve healthcare and provides a consistent national and strategic view in a whole-of-government and system-focused framework, with a person-centered approach to outcomes. This has led to the development of this strategic document by the Ministry of Health for the necessary strategic direction in a coordinated manner.

1.1 GHANA CONTEXT

In Ghana, the surveillance system uses both Indicator-Based Surveillance (IBS) and Event-Based Surveillance (EBS). The indicator-based surveillance system collects well-defined data from several systems including laboratories whilst the Event-Based Surveillance is used to detect disease conditions and events from undefined sources. The implementation of genomic surveillance for infectious diseases, including HIV, TB, and COVID-19, has been an ongoing effort with collaboration from international organizations, research institutions, and global initiatives to strengthen its genomic surveillance capabilities. For example, Ghana has established partnerships with institutions like the Africa Centres for Disease Control and Prevention (AfCDC) and the World Health Organization (WHO) to enhance its genomic surveillance capacity. The country has been actively involved in sequencing SARS-CoV-2 genomes to identify variants and monitor their circulation within its population (WHO-AFRO, 2022).

Ghana is one of Africa's major genomics surveillance contributors, with 5,285 sequences submitted on Global Initiative on Sharing all Influenza Data (GISAID) since January 2020 (Accessed from GISAID



as of 16 October 2023). However, the total sequences deposited only form about 3% of the total reported COVID-19 cases. Ghana has extensive and diverse sequencing platforms located in six institutions namely Noguchi Memorial Institute for Medical Research (NMIMR), West African Centre for Cell Biology of Infectious Pathogens (WACCBIP), National Public Health and Research Laboratory (NPHRL), Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR), University of Health and Allied Sciences Research Laboratory(UHAS), and Genomic and Infectious Disease Laboratory of the Kwame Nkrumah University of Science and Technology (GIDL-KNUST). In addition, Ghana has other laboratories, including the Veterinary Services Directorate, Accra (VSD), and the Council for Scientific and Industrial Research (CSIR) which have the infrastructure for performing genomic sequencing.

Ghana has two major sequencing centers: NMIMR and WACCBIP of which NMIMR is the WHO regional sequencing center supporting four other countries namely: Togo, Liberia, Sierra Leone, and Burkina Faso. These two institutions frequently participate in genomic sequencing external quality assessment for SARS-COV-2 and have conducted sequencing on HIV, Marburg, Mpox, Dengue, Salmonella spp, E. coli, Campylobacter spp, and Antimicrobial Resistance AMR bacteria. The two institutions have together contributed over 50% of Ghana's SARS-COV-2 sequencing data deposited on the GISAID platform. The NMIMR has conducted sequencing of 2,555 pathogens of which 1,611 are uploaded on GISAID.

The KCCR has been conducting sequencing of malaria parasites and selected bacteria prior to the outbreak of COVID-19. The Centre has conducted training for laboratory scientists in the northern part of Ghana in sequencing and analysis of sequencing results. The Centre has sequenced over 100 SARS-CoV-2 samples and deposited about 65 on the GISAID platform. The GIDL of KNUST and UHAS have each contributed 60 and 303 respectively to the GISAID platform.

The US CDC has supported the NPHRL with equipment and logistics for sequencing SARS-CoV-2 and Mpox pathogens. Through training support by NMIMR, the NPHRL has sequenced and uploaded some genomes on the GISAID platform.

1.2 STRATEGY RATIONALE

The health and well-being of the citizens of Ghana is a constitutional requirement as enshrined in the Directive Principles of State Policy of the 1992 Constitution of Ghana. The Government, through State institutions and stakeholders, owes it a sovereign duty to keep all people living in Ghana safe and healthy from all-hazards health threats. This includes protecting the citizenry against global and local health threats posed by infectious diseases. Over the years, Ghana has suffered from the negative impacts of infectious disease outbreaks and from global epidemics and pandemics, such as influenza, Coronavirus disease (COVID-19), Mpox Disease, Marburg Virus Disease, Lassa Fever, and Yellow Fever.

The recent experiences from the COVID-19 pandemic have shown that Ghana needs to put in place mechanisms to prepare adequately for disease surveillance to increase timely sequencing and reporting during public health threats to inform decision making. To help address these recent concerns, the World Health Organization recommended that member states strengthen their genomic surveillance in emergency preparedness as well as make significant investments to expand capacities and harmonize efforts towards developing robust national genomic surveillance systems respectively.



The COVID-19 pandemic showed that health systems need genomic surveillance as an early warning tool for detecting and addressing potential epidemics and pandemics. This technology has been critical in the COVID-19 response, from the identification of the novel coronavirus to the development of the first diagnostic tests, vaccine, and identification of new variants. In line with this background, the Ministry of Health (MoH), in collaboration with its key stakeholders including development partners has taken steps to develop a National Pathogen Genomic Surveillance Strategy.

Developing and implementing a robust genomic surveillance system can have several potential benefits for a country like Ghana as detailed below:

A. Detection of Pathogens and New Variants

Genomic surveillance allows for the identification of emerging and re-emerging infectious diseases, infectious pathogens, variants /strains enabling early detection and response. This helps public health authorities and researchers take proactive measures to contain and control the spread of diseases.

B. Tracking Pathogen Transmission

By analyzing the genetic sequences of pathogens, genomic surveillance tools can help track the transmission patterns, evolution, and geographic spread of diseases. This information is valuable in understanding the spread of disease within and between communities, leading to targeted interventions, and resource allocation.

C. Monitoring Drug Resistance

Genomic surveillance helps identify genetic markers associated with drug resistance in pathogens. This information is crucial for guiding the selection and use of appropriate treatments and minimizing the development and spread of drug-resistant strains.

D. Informing Vaccine Development

Genomic surveillance provides insights into the genetic makeup of pathogens, aiding in the rational development and evaluation of vaccines. It helps monitor the effectiveness of existing vaccines and guides the rational development of new ones to target specific variants or strains.

E. Diagnostic Performance

Genomic surveillance seeks to provide insight into the effectiveness of diagnostic assays. It allows for the monitoring of variations in the sequences of pathogens that enable early detection of diagnostic failures due to sequence variation (diagnostic resistance). Through sequencing, scientists would be able to identify diagnostic targets and design assays promptly to detect epidemic-prone infectious agents.

1.3 SCOPE OF THE STRATEGY

This strategy shall provide an enabling framework for genomic surveillance of all pathogens including viruses, bacteria, and parasites. The target audience for this document is technical staff at human, animal and environmental health sector including academic and research institutions involved in the prevention, management, and control of endemic, epidemic, and pandemic-prone diseases.

The scope shall cover disease surveillance systems particularly adequate availability of reagents and consumables, sample management, diagnostics, analysis, reporting, and sharing of information. The framework is further directed at decision-makers at all levels including national, regional, and district levels. It is primarily a tool to guide the development and implementation of genomic-related strategies, activities, and services. Additionally, the framework will be a useful resource for the private sector, non-government organizations, and communities.



1.4 STRATEGY DEVELOPMENT PROCESS

The Strategy was developed through an evidence-based and extensive participatory process involving reviews of relevant documents, consultations, and dialogue with relevant stakeholders. It was developed under the stewardship of the Minister for Health. The process leveraged the Health Sector Working Group Platform under the chairmanship of the Chief Director of the Ministry of Health for strategic guidance. The day-to-day work was done by a Technical Working Group led by the Director PPME, MoH.

The process also involved the engagement of relevant stakeholders including the Ministry of Health and its Agencies and departments, related health professional bodies, research, academic institutions, and private health sector actors. Other sector Ministries included: the Ministry of Environment Science Technology and Innovation, Ministry of Food and Agriculture, multilateral, and bilateral development partners such as (Africa CDC, WHO, US CDC), private sector service providers, and civil society organizations.

1.5 SITUATIONAL ANALYSIS IN GENOMIC SURVEILLANCE

The situational analysis identified the: strengths, weaknesses, opportunities, and threats on the current situation of genomic surveillance in Ghana in the following areas:

- Testing and Laboratory Services
- Reagents and Consumables
- Transportation and Storage of Samples
- Human Resources
- Network of Laboratories
- Research and Development
- Infrastructure
 - Internet and Data Infrastructure
 - Equipment and Accessories
- High-Quality Timely Data Sharing
- Biosafety and Biosecurity
- Antimicrobial Resistance (AMR)
- Disease Surveillance Systems
- Cost-Reduction and Sustainable Funding Mechanisms
- Genomic Surveillance and One-Health
- Government and Leadership
- Policies and Regulatory Frameworks
- Mentoring and Evaluation

A. Testing and Laboratory Services

Testing and laboratory capacity during the peak of the COVID-19 pandemic, public and private laboratory systems were strengthened to ensure a wide and robust network of laboratories to produce results in a timely manner. The diagnostic strategy for COVID-19 and by extension, epidemic-prone diseases in Ghana includes the use of Nucleic Acid Amplification Technologies (NAATs) as the gold standard and the use of antigen-based Rapid Diagnostic Testing (RDTs) for screening.

There is a network of laboratories with varying diagnostic capacities from the districts through to the National level to diagnose epidemic-prone diseases using PCR technology. These include PHRLs, NMIMR, the KCCR, UHAS, THs, GIDL, WACCBIP, Veterinary Services Directorate and CHAG. In addition, there are about 115 GeneXpert TB machines that were optimized for SARS-COV-2 testing.



At the height of the COVID-19 pandemic, several laboratories were upgraded to provide PCR testing. Currently, most of the PCR machines are being used for routine testing of other pathogens. Despite the presence of molecular testing capacity in these laboratories, only six (6) NMIMR, KCCR, WACCBIP, GIDL, UHAS, NPHRL have the capacity to do genomic sequencing.

A network of well-connected genomic sequencing laboratories can collaborate to ensure that they are not overwhelmed with sequencing capacity during epidemics and/or pandemics. Laboratory surveillance capacity complemented with genomic surveillance can further aid in the successful detection of novel pathogens, variants, or strains and control through integrated systems. The establishment of such systems can help overcome the current challenges of inadequate laboratory infrastructure, reporting-related issues, and logistical issues in the country.

B. Reagents and Consumables

Performing genomic sequencing requires a range of reagents and consumables to ensure accurate and reliable results. Samples commonly used include nasopharyngeal secretions, blood, tissue, or saliva. There are also a variety of reagents, including DNA polymerases, primers, and buffers, library preparation kits and many others that are needed to conduct sequencing. There are different levels of availability of reagents and consumables across laboratories to aid proper storage and cryopreservation of samples which is vital for genomic sequencing. Stocking up on general laboratory consumables, including pipettes, microcentrifuge tubes, and PCR plates are also essential. Stocking up is generally done on a research project basis and not in anticipation of outbreaks of pandemic and epidemic-prone diseases. Additionally, procurement of reagents is dependent on and fragmented along vertical programs such as TB, HIV, Malaria, and Polio. Presently, Ghana lacks the domestic capacity to produce reagents for molecular testing and genomic sequencing.

Also required are bioinformatic software and tools for data analysis, including base calling, alignment, variant calling, and annotation.

C. Transportation and Storage of Samples

In Ghana, many sample referral systems exist and depend on regions and districts with financial support largely driven by TB and HIV programmes. There is also a vertical system for influenza-like illnesses. During the height of the COVID-19 pandemic, the six identified sequencing facilities received samples from across the country for genomic sequencing, however, presently, only two are routinely receiving samples of diseases of public health importance. Health personnel have received training relative to sample management. There is currently a lack of resources to effectively undertake sample transfer and storage.

D. Human Resources

A well-structured human resource development and training programme in the health sector cannot be overemphasized. As a result, the Government has over the years invested in training specialized health professionals. Two (2) Laboratory Scientists from NPHRL have recently received training on the genomic sequencing of SARS-COV-2 at NMIMR. At KCCR, eight (8) research scientists out of the forty (40)-research staff have been trained to conduct sequencing on various platforms. The laboratory network platform includes antimicrobial resistance surveillance, meningitis sentinel surveillance, rabies surveillance, and influenza surveillance. However, these facilities lack specialists such as bioinformaticians and other critical staff. With the support of Wellcome Trust and the UK National Institute of Health and Care Research (NIHR) funding, WACCBIP has established sequencing and bioinformatics training to aid the establishment of a master's degree in bioinformatics.

Though there is a significant improvement in numbers and skills of personnel trained



in genomic sequencing, however, a wide cadre of experts including field epidemiologists, data scientists, and public health specialists are needed to improve the current situation. Other specialists include laboratory scientists, biomedical scientists, veterinary molecular epidemiologists, molecular biologists, and virologists. Furthermore, developing the skill set of local expertise of biomedical engineers to support equipment installation and maintenance would be required. The **table below** gives the breakdown of specialized cadres currently available in the country.

S/N	SPECIALIZED AREAS	NUMBER
1	Doctor of Medical Laboratory Science	226
2	Medical Laboratory Assistant	1042
3	Medical Laboratory Scientist	3070
4	Medical Laboratory Technician	2385
5	Veterinary Laboratory Scientist	72
6	Genomic Sequencing	
7	NMIMR	18
8	WACCBIP	15
9	KCCR	8
10	UHAS	1
11	GIDL-KNUST	3

E. Network of Laboratories

A community of practice will help foster collaborative efforts for the control or eradication of common diseases by building mutual trust for data sharing, strengthening technical capacities, developing joint strategies, harmonizing data reporting systems, and informal routine reporting of potential disease threats. A community of experts in genomic surveillance including human, and animal health practitioners, epidemiologists, ethicists, biostatisticians, bioinformaticians, and veterinarians, needs to be strengthened. This will facilitate the sharing of best practices, affordable laboratory genomic standards, statistical and bioinformatics tools, training materials, and innovations in Ghana and other parts. Currently, there exists some level of community engagement, however, this requires improvement to achieve optimization.

F. Research and Development

Research in genomic surveillance is critical in public health decision-making. Over the years, there has been collaboration between the Ministry of Health and academia in research. Several institutions such as NMIMR, WACCBIP, UHAS, the KCCR contributes to evidence to support decision-making. In addition, the GIDL and the NPHRL all contribute to genomic surveillance in the country. Despite all these, there are weaknesses in funding for research, human resources, and logistics (reagents, supplies, consumables) and weak coordination in leadership. The current research institutions are mostly donor-driven, hence making data ownership a major challenge by hampering the use of research findings for policy decision-making.



G. Infrastructure

Infrastructure for genomic sequencing establishes the framework for workflow safety protocols, data management, and technological integration. Infrastructure such as equipment and accessories, internet and data provide the backbone for conducting genomic surveillance and enabling collaboration among health practitioners.

1. INTERNET AND DATA INFRASTRUCTURE

Data generated during pathogen genomic sequencing must be easily transmitted for improved reporting and prompt decision-making. Such data transmission will require the use of high-performance computers, huge data storage capacity such as servers, high-speed and stable internet connectivity. Ghana is endowed with many high-speed internet providers but its ready access in terms of cost across the country is limited in addition to limited storage capacity. The National Information Technology Agency (NITA) via its Eastern Corridor Fiber network and the government connectivity project through the World Bank is connecting all the 16 regions of the country (including Police Stations, Hospitals, Post Offices, and Metropolitan, Municipal and District Assemblies) to ensure the country is wired. Per the ITU Digital Development Dashboard, Ghana's network coverage is 97% as of 2020; this is foundational to our digital economy.

Despite inadequate internet penetration, there is high-speed internet availability in Ghana. The institutions providing molecular testing and genomic sequencing have access to these services but at a high cost. To overcome these network-related challenges, there is a need for more innovative systems to enable offline reporting and transmission.

2. EQUIPMENT AND ACCESSORIES

Currently capacity in terms of equipment and accessories is adequate to support genomic sequencing in the country. The installed capacity for genomic surveillance in Ghana includes three Illumina platform sequencing machines, five Oxford nanopore technology platform sequencing machines, (two GridION, six MinION MK1C, and twelve MinION MK1B), one ThermoFisherScientific platform sequencing machines (Ion torrent PGM), one 10x genomics platform a computing platform (made of five servers and a high-performance computer), and automated NGS library preparation platform (Hamilton, UK). However, there are no service agreements for periodic maintenance schedules.

A. High-Quality Timely Data Sharing

Data is critical to every genomic surveillance system. To ensure that data analyses are optimal for decision-making, close attention should be paid to the quality and timeliness of the data (and genomic metadata). In Ghana, the sharing of sequencing data from epidemic-prone diseases is not adequately structured and sometimes, not timely enough for decision-making. Currently, there is no well-defined national system in place for reporting sequencing data. There is therefore the need to establish a national system for reporting genome sequencing data. Collaboration from global, regional, or national agencies is needed to boost the capacities and efficiency of disease detection and response in resource-constrained settings.

B. Biosafety and Biosecurity

Laboratory biosafety and biosecurity activities are important in protecting the laboratory workforce, wider community and the environment against unintentional exposures or release of pathogenic biological agents. These activities are implemented through a



risk assessment and the development of a safety culture which is needed to minimize the likelihood and severity of any potential exposure. New technologies, especially the use of molecular methods, have reduced the number of activities requiring the culture of biological agents. However, the establishment of sequencing laboratories will require some level of biosafety and biosecurity measures to be implemented through provision of biosafety cabinets, safety hoods, adequate laboratory space and installation of well protected security systems. In addition, emerging global trends in biological warfare, bioterrorism, biological accidents, and harmful consequences arising from dual-use biotechnology also pose a challenge for global biosecurity. Improving the early surveillance capabilities, such as the introduction of genomic surveillance activities are necessary for building a common biosecurity shield for the global community of health for all.

Effective implementation of biosafety and biosecurity systems should be supported by established laws, policies, and guidelines at national and institutional levels. Ghana currently has a National Biosafety Authority which exercises general supervision and control over the transfer, handling, and use of Genetically Modified Organisms (GMOs). This is backed primarily by the Biosafety Act, of 2011(Act 831). Act 831 is yet to be revised to regulate laboratory biosafety and biosecurity. In the absence of a national regulatory framework, a National Biosafety and Biosecurity Guide for Laboratories has been developed to guide laboratory practices and safety standards. A biosafety and biosecurity training manual has also been developed to guide the training and capacity building of laboratory staff to ensure safety standards are adhered to.

However, current surveillance systems face enormous challenges, including technical shortages, fragmented management, and limited international cooperation. Detecting emerging biological risks caused by unknown or novel pathogens is of particular concern.

The introduction of genomic surveillance systems will effectively mitigate biosecurity risks. Agencies such as the FDA, HeFRA, and GSA continue to provide oversight to laboratories to ensure personnel, equipment, and environmental standards are maintained to ensure the containment of pathogens.

C. AMR and Genomic Surveillance

Antimicrobial Resistance (AMR) is a major global threat of increasing concern to human, animal, and environmental health, exacerbated by excessive use and misuse of antimicrobials. In Ghana, there are some activities on genomic surveillance to detect AMR pathogens. Some current AMR activities include surveillance of Methicillin-Resistant *S. aureus* (MRSA), Extended-Spectrum Beta-Lactamase (ESBL) producing bacteria, drug resistance tuberculosis bacteria and other GLASS priority pathogens as well as ESKAPE pathogens. The whole genome sequencing of bacteria species provides essential information for profiling of resistance genes associated with pathogens.

Data from AMR surveillance activities at NMIMR has resulted in the sequencing of over 2,500 bacterial genomes (from humans, animals, and the environment) revealing global epidemic clones carrying multiple resistance and virulence genes. Also, through its efforts toward reducing the TB burden in Ghana, it has sequenced and analyzed over 800 *Mycobacterium tuberculosis* genomes. The KCCR has conducted sequencing of targeted resistance genes of malaria parasites and bacteria genomes using its Seqstudio genetic analyser. The challenge is to expand the existing national action plan on AMR to cover genomic sequencing in the veterinary service Ghana.

D. Disease Surveillance System

Ghana's disease surveillance system has been implementing the Integrated Disease Surveillance and Response (IDSR) strategy developed by the World Health Organisation since 2002. The IDSR has undergone three



main revisions, and the 3rd edition is currently being implemented at all levels with the aim of early identification, reporting and responding to public health threats in the country. There are currently 55 priority diseases, conditions and events covered by the IDSR.

An electronic IDSR (eIDSR) platform is being implemented across all districts in the country to help with the ease of data transmission from the point of sample taking to testing laboratories. The IDSR implementation has been successful in detection and response to multiple disease outbreaks in Ghana including the first-ever recorded outbreak of the Marburg Virus Disease in 2022. Significant improvements in the reporting of priority diseases under surveillance through the networking of laboratories and linkage to the eIDSR platform have contributed to this.

In the Animal Health Sector, VSD also implement the World Organization of Animal Health (WOAH) surveillance tools which has been adopted in the animal disease surveillance in Ghana using the FAO EMA-I and SILAB platforms for reporting. The pilot phase has been successful, and it is expected to be rolled out across the country. Selected laboratories in the animal sector report human data on the eIDSR platform for specific conditions like rabies, COVID-19, and Anthrax.

Despite this progress, the eIDSR platform does not cover all the genomic sequencing laboratories and has no component for uploading sequencing results. Also, some challenges exist particularly with eIDSR implementation such as the availability of tablets, system challenges, and mobile network connectivity among others. The Ghana Health Service is working with partners and other agencies of the MoH including the FDA, Teaching Hospitals and CHAG, MMDAs such as the Ministry of Communications and the National Communications Agency to strengthen eIDSR implementation and address these challenges. There is a need for the IDSR system to incorporate the aspect of genomic surveillance as part of its strategic activities.

E. Cost-reduction and Sustainable Funding Mechanisms

Though genome sequencing costs are relatively decreasing due to technological advancements, market competition, intense competition, and new players with innovative approaches, the per-sample cost for sequencing infectious agents is estimated at around \$80 to \$100 in Africa. This makes it substantially higher in Africa than in other areas, partly due to profit margins set by local companies and distributors, in addition to shipment and customs costs. This makes genomic surveillance expensive for it to be considered as a routine diagnostic tool. However, the cost can be greatly reduced through techniques such as multiplexing, tax waivers, and accurate quantifications. Other approaches could include bulk procurement through regional or continental systems. Genomic surveillance will need to be considered as part of the broader public health goods and as part of national disease control and emergency response programs. Developing a sustainable resource framework for genomic surveillance is critical. This can be used to solicit support from other funding sources like the global fund and other partners to jointly facilitate the expansion of genomics in the country.

F. Genomic Surveillance and One Health

A key lesson from the COVID-19 pandemic is that pathogens can emerge and spread from nature at any time. This makes it imperative for the sequencing strategy to incorporate a “One Health” approach to improve linkage between sectors, including human, veterinary, food health, and the environment. Implementing a genomic cross-species surveillance (one health) would not only enable earlier detection of pathogens and their transmission within and between species, but also, allow outbreak clusters to be accurately identified from the analysis of epidemiological information about the relationship between different individual pathogens. Ghana has drafted a One Health policy which highlights the need for a genomic surveillance strategy.



G. Governance and Leadership

Currently, Ghana has a Public Health Division that coordinates all surveillance activities. For genomic surveillance, the Ministry of Health has established a laboratory network/network of laboratories with a technical working group that oversees the operations of the network. As Ghana positions itself as a medical tourism hub for advanced medical care, the network is an opportunity to support the training of a skilled workforce, establish, and coordinate a functional pan-African laboratory network with sample shipment and quality-assured testing, the effective functioning of the community of practice, among other contributions. The Ministry of Health will provide leadership, oversight, and coordination to enhance a sustainable genomic surveillance system for emerging epidemic and pandemic-prone infectious diseases. Currently, there is no coordination at the leadership level for genomic sequencing. A technical working committee to provide technical support is also non-existent. The network of laboratories exists but does not cover genomic surveillance. Presently, although there are structures in place to support expansion in genomics sequencing, a formal leadership and coordination mechanism for genomic surveillance ought to be prioritized.

H. Coordination Mechanisms for Genomic Surveillance

Integrating genomic surveillance into public health including defining the circumstances, when and from where samples should be taken for genomic sequencing will require enabling policies, strategies, and regulatory mechanisms. Establishing a functional pathogen genomics network that relies on shared resources and joint efforts for cross-border disease control and elimination within the continent will require an effective coordination mechanism and a harmonized legal framework. This collaboration also includes mobilizing resources for capacity building and helping develop policies and standards, facilitating bulk purchasing, and negotiating pricing with manufacturers.

DATA PROTECTION

Ensuring genomic data privacy is critical in healthcare due to the sensitive nature of genetic information. This will require the development of several technical and legal mechanisms to protect genomic data from unauthorized access. These mechanisms can facilitate good practice in the collection, storage, and use of specimens, and specimen transfer within and between countries as well. In Ghana, there are some established data protection mechanisms under National Information Technology Agency (NITA), the Data Protection Act, 2012 (Act 843), Surveillance Outbreak Response Management and Analysis System (SORMAS) and any other platforms used for storing genomic surveillance data.

There is a need to strengthen existing data protection mechanisms in line with data protection standards.

MONITORING AND EVALUATION

Regular monitoring and assessments of the efficiency and effectiveness of incorporating genomic data in routine public health surveillance systems are crucial. Though monitoring for developing effective prevention strategies, diagnostic tools, vaccines, and targeted treatments is essential, however, there is no formal evaluating schedule for public health surveillance. **Building internal and external quality control mechanisms for sequencing data is paramount.** There are available tools for evaluating public health surveillance systems. For effective genomic surveillance, the country should employ tools for monitoring and evaluating genomic surveillance. This evaluation should include assessing the completeness and timeliness of data collection, reporting on, and using the data for decision-making. It should also seek to identify gaps and areas for improvement and assess the costs and benefits of the genomic data compared with other surveillance approaches.



02 CHAPTER TWO

2.0 STRATEGY CONTEXT AND FRAMEWORK

This National Genomic Surveillance Strategy acknowledges several global, regional, and sub-regional compacts and policy frameworks that support the broader health sector vision of ensuring a healthy population for national development.

2.1 GLOBAL CONTEXT

S/N	DOCUMENT	CONTENT
1	Sustainable Development Goals (SDGs)	Ensuring healthy lives and promoting well-being for all at all ages is goal 3 . In addition, the aim is to achieve universal health coverage, provide safe and effective vaccines to all, and undertake supporting research.
2	World Health Assembly- Global Strategy for Health for All by 2000 (Resolution 32.30)	This strategy calls upon member countries to make a concerted effort to develop health systems. To develop the health systems a supportive genomic referral system is required.
3	International Health Regulations (2005)	The International Health Regulations (2005) (IHR) provide an overarching legal framework that obligates countries to respond to public health threats in a way that limits their spread to other countries. It also provides for collaboration between countries and data sharing. The IHR is currently undergoing some review to address issues including pathogen data sharing. It seeks to define countries' rights and obligations in handling public health events and emergencies that have the potential to cross borders.



4	2018 Astana Kazakhstan Declarations	The October 2018 Astana Kazakhstan Declarations by Heads of States and Governments, Ministers, and representatives of countries at the Global Conference on Primary Health Care seek to prioritize, promote, and protect people's health and well-being, at both population and individual levels, through strong health systems.
5	Global Genomic Surveillance Strategy for pathogens with pandemic and epidemic potential (2022-2023)	WHO's global strategy which seeks to provide a high-level unifying framework to leverage existing capacities, address barriers and strengthen the use of these tools worldwide.
6	Considerations for developing a national genomic surveillance strategy or action plan for pathogens with pandemic and epidemic potential	This document outlines key considerations and informs a systematic approach to developing a national genomic surveillance strategy for pathogens of pandemic and epidemic potential.
7	WHO Guiding Principle for data and information sharing, 2022	WHO is committed to strengthening the global ecosystem of public health data. This includes building internal data governance capacity. The WHO data principles act as the foundations for data-related policies, plans and programme implementation.
8	WHO Framework on Molecular methods for antimicrobial resistance (AMR)	This provides a framework for countries and healthcare systems to monitor and address AMR effectively. Implementing molecular methods for AMR surveillance can help monitor the spread of resistant pathogens, inform treatment decisions, and guide efforts to preserve the effectiveness of antibiotics.
9	WHO Manual for the laboratory diagnosis and virologic surveillance of influenza	This helps countries and healthcare systems monitor and respond to influenza outbreaks effectively, whether they are seasonal epidemics or potential pandemics. Timely and accurate surveillance of influenza viruses is essential for public health decision-making, vaccine development, and pandemic preparedness.



AFRICAN REGION

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| 10 | Agenda 2063: The Africa we want | Africa's blueprint and master plan for transforming Africa into the global powerhouse of the future. It is the continent's strategic framework that aims to deliver on its goal for inclusive and sustainable development. |
| 11 | The African Health Strategy (2016-2030) | The strategy adopts and promotes a paradigm shift in addressing public health threats from Natural and man-made disasters including building national, regional and continental capacity to address disaster. |
| 12 | The Africa Health Transformation Agenda (2015-2020) | It provides a vision for universal health coverage and is the strategic framework that will guide WHO's contribution to the emerging sustainable development platform in Africa. |
| 13 | The Ouagadougou Declaration on PHC and Health System 2008. | The Ouagadougou Declaration on Primary Health Care and Health Systems in Africa focuses on nine major priority areas instead of the WHO 6 building blocks. The additions are: Community Ownership and Participation; And Partnerships for Health Development; and Research for Health. |
| 14 | The Accra Declaration on Universal Health Coverage, 2022 | This declaration emphasizes that health services cover the whole spectrum of promotive, preventive, curative, rehabilitative, and palliative care and ensure the package include mental health, Sexual and Reproductive Health (including family planning), and emergency services to ensure no one is left behind (especially the youth, women, children). |



2.2 NATIONAL CONTEXT

The strategy derives inspiration from **Article 34 (2)** of the 1992 Constitution of the Republic of Ghana- *Directive Principles of State Policy* which amongst others requires the state to ensure, the realization of the right to good health care. It has also been inspired by the overall national policy framework developed by the National Development Planning Commission called the Coordinated Program of Economic and Social Development Policies (2021-2025). It further recognizes some other key national policy and strategic frameworks including:

- National Health Policy, 2020 (NHP, 2020)
- Universal Health Coverage Roadmap for Ghana (2020 – 2030)
- National Strategic COVID-19 Response Plan (2020 – 2024)
- Strategy on Antimicrobial Use and Resistance (2017)
- The Antimicrobial Resistance Policy.
- Ghana National Healthcare Quality Strategy, 2017-2021
- National Medicines Strategy 2017
- The Essential Health Service Package (2022)
- The Public Health, 2012 Act 851
- National Blood Policy, 2020
- Biosafety Act of 2011(Act 831).
- Biosafety (Management of Biotechnology) Regulations, 2019 (L.I 2383).

2.3 VISION, MISSION, AND GOAL

2.3.1 Vision of MoH

A healthy population for national development.

2.3.2 Mission of the MoH

The mission is to contribute to the development of a local health industry by ensuring that all people living in Ghana live longer and better using motivated personnel for improved population health in a coordinated manner.

2.3.3 Goal of the Strategy

The goal of the strategy is to promote, strengthen, and scale up genomic surveillance for pathogens with epidemic and pandemic potential for quality, timely, and appropriate public health actions within local and global surveillance systems.

2.3.4 Guiding Principles

The smooth implementation of the strategy is hinged on the following guiding principles:

Collaboration and Country Ownership

To advance knowledge and fuel innovation in genomics, the Ministry of Health will work collaboratively at the national and international levels for the benefit of all players. It will further seek to build and own a stronger national genomic surveillance system for health emergency preparedness and response in line with international regulations and standards.



Ethics

To ensure that inputs, outputs, and outcomes uphold the fundamental ethical principles of respect, goodwill, and justice and not cause harm, the use of personal data will meet the highest ethical principles for clinical practice and research.

Equity

This strategy recognizes that the interventions and health-related resources required to meet the needs of the population will be prioritized where necessary to ensure a fair distribution to both public and private health reference laboratories and no facility will be unfairly discriminated against.

Sustainability

Internal structural programmes, capabilities, and capacities according to a needs-based approach for easy implementation by all players will be developed. The governance structure should strive to ensure efficient and effective administration of genomic systems and align to other platforms for easy comparison.

Transparency

The conditions for dissemination of information, regulation, and other laws governing surveillance should be made public and available to all stakeholders. All key players should understand their roles and responsibilities and what is always expected of them. Governance procedures, for example, in the constitution of boards and committees and their terms of reference should be publicly available and clear to all.

03 CHAPTER THREE

3.0 STRATEGIC OBJECTIVES AND INTERVENTIONS FOR THE FIVE (5) YEARS

National Genomic Surveillance Strategy (2024-2028) has five (5) key strategic objectives with its accompanying strategic interventions as indicated below.

Objective 1: Improve access to infrastructure and logistics for genomic surveillance.

Objective 2: Improve sample management, data capture, storage, analysis, use, and management.

Objective 3: Strengthen human resource capacity for genomic surveillance.

Objective 4: Strengthen innovation and research in genomics.

Objective 5: Strengthen governance in genomic surveillance.

3.1 STRATEGIC OBJECTIVE 1: IMPROVE ACCESS TO INFRASTRUCTURE AND LOGISTICS.

Harnessing the power of genomic technologies for emergency preparedness requires improvement in infrastructure to collect, test, store, process, and analyse samples for timely decision-making. Strengthening laboratory infrastructure to optimize genomic sequencing will therefore be paramount in Ghana's quest to be a key player in the genomics-space both locally and internationally.

3.3.1 Strategic Interventions

- Improve timely availability of reagents, consumables, and logistics/ for genomic sequencing.
- Improve maintenance of functional equipment.
- Build and upgrade existing infrastructure for genomic surveillance.
- Ensure the creation of a sustainable genomic surveillance system.



3.2 STRATEGIC OBJECTIVE 2:

IMPROVE SAMPLE MANAGEMENT, DATA CAPTURE, STORAGE, ANALYSIS, USE, AND MANAGEMENT.

The collection and analysis of genomic data is essential to drive improvements in health outcomes of the population during emergencies.

3.2.1 Strategic Interventions

- Integrate genomic data into the existing electronic surveillance system.
- Improve sample management.
- Strengthen data protection mechanisms.

3.3 STRATEGIC OBJECTIVE 3:

STRENGTHEN HUMAN RESOURCE CAPACITY FOR GENOMIC SURVEILLANCE.

Building a skilled workforce that is literate in genomics by upskilling the workforce through increasing capacity and capability in genomics and bioinformatics is key for effective and efficient support of improved health outcomes for the individual and population.

3.3.1 Strategic Interventions

- Develop training programmes for genomics and bioinformatics.
- Train laboratory scientists, bioinformaticians, and other relevant health workers.
- Establish a competency assessment program for all trained staff.
- Develop training programs on Biosafety and biosecurity.
- Recruit specialized personnel (bioinformatics, epidemiologist, and related technicians).

3.4 STRATEGIC OBJECTIVE 4:

STRENGTHEN INNOVATION AND RESEARCH IN GENOMICS.

Advancements in research and innovation in genomics is paramount as it brings confidence and continuous learning and development in the field for a better patient outcome. This will simultaneously drive economic growth through collaboration and partnership with academia and industry.

3.4.1 Strategic Interventions

- Strengthen research and innovation for genomic surveillance.

3.5 STRATEGIC OBJECTIVE 5:

STRENGTHEN GOVERNANCE IN GENOMIC SURVEILLANCE.

Building a strong leadership and governance structure that promotes centres of excellence, multi-sectoral collaboration and partnership between national public health institutes, academia, and commercial laboratories for the necessary infrastructure, enabling environment, and secures the needed resources is vital for the smooth implementation of this strategy.

3.5.1 Strategic Interventions

- Establish a governance structure to coordinate genomic surveillance activities.
- Develop a framework to support and mobilize resources for genomic surveillance.
- Strengthen Monitoring and Evaluation systems.
- Improve both domestic and international collaboration and coordination for genomic surveillance.
- Develop guidelines for sample management for genomic sequencing.
- Develop standards and guidelines for genomic data.
- Strengthen regulation in genomic surveillance.

04 CHAPTER FOUR

4.0 STRATEGY IMPLEMENTATION ARRANGEMENTS AND PLAN

4.1 Strategy Implementation Arrangement

The implementation arrangement for this five-years strategy (2024-2028) is designed to ensure that there is effective coordination, collaboration, and harmonization of efforts of all stakeholders involved in genomic surveillance activities. The roles of the relevant institutions indicated as below:

4.1.1 Ministry of Health

The Ministry of Health shall have oversight responsibility over the full implementation of this strategy. It shall ensure that all relevant institutions (both public and private) provide high-quality genomic sequencing services for better health outcomes for all people in Ghana. Specifically, the MoH shall among other functions:

- Coordinate the efforts of all relevant stakeholders to ensure full implementation of the National Genomics Surveillance Strategy.
- Ensure optimal dissemination of the strategy to all relevant stakeholders.
- Collaborate with relevant stakeholders to undertake periodic performance monitoring and evaluation of the strategy.
- Establish mechanisms and partnerships and develop framework for sustainable funding for genomic surveillance.
- Develop the necessary standards, guidelines, and governance structure to strengthen regulation in genomic surveillance.

4.1.2 Ministry of Environment, Science, Technology, and Innovation

The Ministry of Environment, Science, Technology, and Innovation is responsible for the development of the environment and science in Ghana. The Ministry exists to promote sustainable environmental management and the adoption and application of science and technological innovations through the formulation of policies, monitoring, and evaluation of the implementation of sector plans, programs, and projects for national development which aligns with the quest to promote genomic sequencing. It further seeks to:



- Promote the development and use of information and communication technology (ICT) in Ghana to enhance various sectors, including education and healthcare.
- Support and promote scientific research and development activities that contribute to technological advancements and innovation.
- Oversee the establishment and enforcement of standards in various technological sectors to ensure the quality and safety of products and services.

4.1.3 Ministry of Food and Agriculture

The Ministry of Food and Agriculture (MoFA) is the lead agency and focal point of the Government of Ghana, responsible for developing and executing policies and strategies for the agriculture sector. The MoFA has oversight responsibility of the livestock and fisheries sub-sectors of Ghana, which plays a key role in the One Health agenda. It seeks to undertake the following which is vital to the growth and expansion of genomic surveillance in Ghana:

- Solicit for funding and collaboration with research institutions and scientists to advance one health agenda.
- Collaborates with various research institutions and universities internally and externally to harness scientific knowledge and expertise in animal health and livestock management.
- Contribute to capacity-building efforts, including training in animal science in modern techniques, pest control, and animal husbandry practices based on scientific principles.

4.1.4 Ministry of Education

The ministry often collaborates with other government agencies, educational institutions, and international organizations to enhance the quality of science education in Ghana. The ministry may initiate programs and policies to promote STEM (Science, Technology, Engineering, and Mathematics) education. The ministry will be responsible for developing and updating the curriculum for science education at all levels that meet international standards and promote a strong foundation in science subjects such as biology, chemistry, and physics. These in fact can contribute to the foundation of genomic right from the lower level of science education in Ghana hence a strong foundation for genomic surveillance.

4.1.5 Other Relevant Ministries, Departments and Agencies

The MoH will collaborate with other Ministries, Departments, and Agencies whose mandates are directly or indirectly related to genomic surveillance aside the Ministries mentioned above. The matrix below gives a detailed description of the roles and responsibilities of some of the implementing institutions.

4.1.6 Private Sector

The Ministry of Health will partner with all private facilities, corporate institutions and all interested organization committed to supporting the achievement of the strategy objectives. These partnerships shall be facilitated by the MoH to ensure transparency, fairness, and equitable spread of partnerships with government.



4.2 Roles and Responsibility Matrix

Objectives	Strategies	Responsibility	
		Lead MDA	Collaborators
Objective 1: Improve access to infrastructure and logistics.	■ Improve timely availability of reagents, consumables, and logistics for genomic sequencing. ■ Improve maintenance of functional equipment. ■ Build and upgrade existing infrastructure for genomic surveillance. ■ Ensure the creation of a sustainable genomic surveillance system.	Lead: MoH Co-Lead: MoE/ MoFA/MESTI	GHS, DPs, Private Sector, NMIMR, KCCR, GIDL, WACCBIP, VSD, UHAS, Teaching Hospitals, EPA, CSIR, FDA, HeFRA, Professional regulatory agencies
Objective 2: Improve sampling, data capture, storage, analysis, use and management.	■ Integrate genomic data into the existing electronic surveillance system. ■ Ensure the creation of sustainable, integrated, and user-friendly technologies. ■ Improve sample management.	Lead: GHS Co-lead: MoH	NMIMR, KCCR, WACCBIP, VSD, UHAS, GIDLNCCRM, Teaching Hospitals, CSIR, NIITA
Objective 3: Strengthen human resource capacity for genomic surveillance.	■ Develop training programmes for genomics and bioinformatics. ■ Train laboratory scientists, bioinformaticians, and other relevant health workers. ■ Establish a competency assessment program for all trained staff. ■ Develop training programs on Biosafety and biosecurity. ■ Recruit specialized personnel (bioinformatics, epidemiologist, and related technicians).	Lead: MoH Co-Lead: MoE	GHS, NMIMR, KCCR, WACCBIP, GIDL, UHAS, VSD, GCPS, AHPC, Teaching Hospitals, Ghana Police Service (Forensic Laboratory), DPs, GTEC



Objective 4: Strengthen Innovation and Research in genomics.	Strengthen research and innovation for genomic surveillance.	Lead: MoH Co-Lead: MESTI, MoE, MoFA,	NMIMR, KCCR, WACCBIP, VSD, GCPS, GIDL, UHAS, WACMLS, GHS, Teaching Hospitals, UHAS, CSIR, DPs, CSOs, Private sector
Objective 5: Strengthen Governance in genomic surveillance.	- Establish a governance structure to coordinate genomic surveillance activities. - Develop a framework to support and mobilize resources for genomic surveillance. - Strengthen Monitoring and Evaluation systems. - Develop guidelines for sample management for genomic sequencing. - Improve both domestic and international collaboration and coordination for genomic surveillance. - Strengthen regulation in genomic surveillance. - Develop standards and guidelines for genomic data.	Lead: MoH Co-Lead: MESTI, MoFA,	Parliament of Ghana, MoJAGD, GHS, VSD, NMIMR, KCCR, WACCBIP, UHAS, GIDL, NCCRM, CSOs, Private sector

4.3 Resource Mobilisation

Mobilizing the requisite resources is key for the effective implementation of this strategic document. These include financial and human resources as well as materials/logistics. It shall be the responsibility of the MOH to mobilize resources from both local entities and international organizations to implement the National Genomic Surveillance Strategy. Financing options will include but not limited to:

1. GoG Budgetary Support
2. Internally Generated Funds
3. Development Partner(s) Support
4. Corporate Bodies
5. Civil Society and Non-Governmental Organizations
6. Public Private Partnerships (PPP)

05 CHAPTER FIVE

5.0 MONITORING AND EVALUATION

Monitoring will be the direct responsibility of the Ministry of Health with the support of the relevant stakeholders. It will be routine and continuous (quarterly, half-yearly, and annual). The agreed set of indicators and reporting formats shall be spelt out in the implementation framework. The Strategies for monitoring and evaluation will be considered pertinent in the implementation of this strategy. Result frameworks on each strategy detailing outputs, outcomes, impacts and key actions shall be developed.

Appendix 3 provides the framework for developing annual implementation and monitoring plans for tracking the performance of the national genomic strategy. Monitoring and evaluation will aim at:

- Supporting research and studies whose findings and conclusions could be used to enhance stakeholders' understanding of genomic surveillance.
- Assisting stakeholders in operationalizing the strategy to generate and relevant indicators to measure performance.



06 CHAPTER SIX

6.0 COMMUNICATION AND STRATEGY DISSEMINATION PLAN

A communication and strategy dissemination plan will form a major component of the National Strategy implementation and it will serve as a major driver to motivate and inspire all implementing institutions to achieve the desired objectives. The dissemination process will ensure that the key stakeholders and partners understand the tenets of the document as well as have a buy-in. It will further create awareness, empower the population as well as generate population interest in genomic sequencing. The communication plan will be activated within the existing structures of MOH as outlined in the Common Management Arrangement (CMA). The following existing systems and structures shall therefore be leveraged for the dissemination of the strategy.

- The Inter-Agency Leadership Committee (IALC)
- The Health Sector Working Group (HSWG) meetings.
- Business Meetings
- Annual Health Summit
- Decentralized Level Dialogue
- Annual Strategy Dialogue
- Others

The Ministry of Information (MoI), the National Commission for Civic Education (NCCE) and the Information Services Department will also play a part in disseminating the strategy.



6.1 AUDIENCE

- Ministry of Health and its Agencies
- Ministries, Departments, and Agencies
- Civil Society and Non-State Actors in Health
- Development Partners
- Parliamentary Select Committees on Finance and Health
- The Media
- Others

6.2 OBJECTIVE

The objectives of the communication strategy are to:

- Seek ownership and buy-in from all stakeholders for smooth implementation of the Strategy.
- Inform and assure the public of the government's commitment to achieving Universal Health Coverage (UHC) by improving genomic sequencing services at all levels.
- Sensitize stakeholders on their roles and responsibilities.
- Sensitize stakeholders on the institutional and implementation arrangement of the Strategy.



Appendix 1 Strategic Action Plan

Strategic objective	Strategic Interventions	Main activities	Identification of risks	Risk mitigation
1. Objective: Improve access to Infrastructure and Logistics for Genomic Surveillance.	1.1. Improve timely availability of reagents, consumables, and logistics/ for genomic sequencing.	1.1.1 Conduct genomic needs assessment 1.1.2. Integrate genomic reagents and supplies in the national procurement plan.	• Non-availability of funds • Lack of essential genomic supplies • Delays in procurement	• Identification of key genomic facilities. • Identify sources of funding and advocate for ring-fencing • Make funds available for infrastructure and logistics
	1.2 Improve maintenance of functional equipment	1.2.1 Undertake regular training to build the internal capacity of staff on equipment operation, maintenance, and troubleshooting. 1.2.2. Undertake regular training to build external maintenance contracts for key equipment. 1.2.3 Develop standard guidelines for equipment maintenance. 1.2.4 Capacity building for biomedical engineers.	• Limited financial resources • Attrition of trained staff • Non-availability of equipment parts	• Advocate for funding. • Advocate for staff retention. • Advocate for frequent maintenance
	1.3 Build, expand, and retool existing infrastructure for genomic surveillance.	1.3.1 Upgrade sequencing platform to procure advanced versions of sequencing equipment	• High cost of shipping • Limited funding	• Advocate for discount in clearance duty. • Resource mobilization
		1.3.2 Expand and or build existing and new laboratories for genomic sequencing.	• Weak collaboration	
		1.3.3 Procure computers and accessories for data analysis	• Long procurement process • Non-availability of funds	• Early engagement of procurement staff • Dedicated funding
	1.4 Ensure the creation of a sustainable and genomic surveillance system.	1.4.1 Ensure collaboration between industry and academia. 1.4.2 Integrate genomic surveillance into IDSR.	• Weak leadership and governance structures • Lack of coordination	• Strengthen coordination



Objective 2: Improve sample management, data capture, storage, analysis, use, and management.	2.1 Integrate genomic data into the existing electronic surveillance system.	2.1.1 Procure robust data management system and high-capacity storage solutions for genomic data. 2.2.2 Train personnel in advanced genomic techniques, bioinformatics, and data analysis. 2.1.3 Integrate genomic data with existing public health information systems to enhance its utilization. 2.2.4 Develop protocols for real-time data sharing among relevant stakeholders.	• Lack of high-level capacity systems • Weak investment • Lack of trained staff in data analysis • Weak collaboration • Lack of funding	• Advocate for funding. • Invest in electronic surveillance systems, • Advocate for support. • Involve more partners
	2.2 Improve sample management	2.2.1 Train all stakeholders in sample management. 2.2.2 Procure sample management consumables. 2.2.3 Improve sample referral networks. 2.2.4 Develop a protocol for representative sampling for pathogens of interest for genomic surveillance.	• Delay in sample procurement, • Lack of funds • Weak leadership network	• Mobilize resource. • Streamline leadership role



Objective 3: Strengthen human resource capacity for genomic surveillance.	3.1 Develop training programs for genomics and bioinformatics.	3.1.1 Organize regular capacity-building programs like workshops, webinar's, on lines course etc) specialized personnel.	• Attrition of trained staff • Limited financial clearance • Delays in administrative process	• Training and certification • Advocate for funding. • Intensify engagement
	3.2 Train laboratory scientists, bioinformaticians, and other relevant health workers.	3.2 Train and certify personnel laboratory scientists, bioinformaticians, and other relevant health workers.	• Attrition of trained staff • Delays in recruiting laboratory scientist	• Training and certification • Advocate for financial clearance
	3.3 Establish a competency assessment program for all trained staff.	3.3.1 Establish an EQA programme for genomic sequencing. 3.3.1 Conduct regular competency-based assessment for critical staff personnel.	• Delay in the assessment process. • Lack of funding	• Advocate for support
	3.4 Develop training programs on biosafety and biosecurity.	3.4.1 Training of staff in safety measures and other occupational safety hazards.	• Staff migration • Inadequate Resource persons.	• Mobilize resource persons
	3.5 Recruit specialized personnel (bioinformatics, epidemiologist, and related technicians).	3.5.1 Conduct skills gap analysis		
Objective 4: Strengthen Innovation and Research in genomic.	4.1 Strengthen research and innovation for genomic surveillance.	4.1.1 Develop a research agenda to advance research in genomic surveillance.	• Weak collaboration • Inadequate scientist available • Lack of investment and funds	• Engagement of key stakeholders • Recruit more scientists. • Resource mobilization
		4.1.2 Establish structures for data ownership and sharing, consent, confidentiality, and international collaboration.		
		4.1.3 Support research for new genomic technologies for efficient and accurate surveillance.		
		4.1.4 Advocate for dedicated and adequate funding for genomic research and innovation.		



Objective 5: Strengthen Governance in genomic surveillance.	5.1 Establish a governance structure to coordinate genomic surveillance activities.	5.1.1 Develop TOR and framework for GSS governance structure. 5.1.2 Implement GSS governance framework.	• No outlined governance mechanism for implementing GSS strategy.	• Leverage GSS TWG to develop governance framework.
	5.2 Develop a framework to support and mobilize resources for genomic surveillance.	5.2.1 Develop a resource mapping framework to mobilize adequate resources for improved genomic surveillance. 5.2.2 Implement the framework and ensure equitable resource distribution. 5.2.3 Advocate for funding for genomic sequencing.	• Administrative delays-late release of funds • Lack of funds	• Streamline administrative system. • Prioritize High-level advocacy.
	5.3 Strengthen Monitoring and Evaluation systems	5.3.1 Develop a monitoring and evaluation system. 5.3.2 Constitute high level national genomic surveillance Committee. 5.3.3 Undertake annual regular supportive supervision monitoring visits.	• Lack of leadership commitment	
	5.4 Improve both domestic and international collaboration and coordination for genomic surveillance.	5.4.1 Establish collaboration between researchers, institutions, and industry to facilitate the exchange of knowledge and resources. 5.4.2 Foster partnership among between public institutions and private entities including biotechnology and pharmaceutical companies for infrastructure support. 5.4.3 Establish collaboration and networking with the genomic community at national and international around genomic research.	• Weak collaboration • Weak leadership • Weak funding • Administrative bottlenecks	• Engagement of key stakeholders • Resource Mobilization • Streamline administrative system.
	5.5 Develop guidelines for sample management for genomic sequencing.	5.5.1 Develop training manuals and guidelines for genomics surveillance.	• Administrative delays • Weak funding sources	• Streamline administrative procedures. • Mobilize adequate funds
	5.6 Develop standards and guidelines for genomic data.	5.6.1 Develop an interoperability database that can store and share data, facilitate collection and information exchange for different research and public health institutions.		
	5.7 Strengthen regulation in genomic surveillance.	5.7.1 Revise the public health act to include genomic surveillance.		



Appendix 2 - Operational Plan – (Year-1)

Strategic Interventions	Main activities	Sub-Activities	Responsibility	Turnaround time	Cost
1.1 Improve timely availability of reagents, consumables, and logistics/ for genomic sequencing.	1.1.1 Conduct genomic needs assessment	• Develop Terms of Reference (ToR) • Procure a consultant. • Organize Technical Working Group meetings. • Organize Stakeholder validation workshop.	MoH		
	1.1.2. Integrate genomic reagents and supplies in the national procurement plan.	• Organize Technical Working Group meetings. • Organize stakeholder validation workshop.	MoH		
1.2 Improve maintenance of functional equipment	1.2.1 Undertake regular training to build the internal capacity of staff on equipment operation, maintenance, and troubleshooting.	• Organize training workshop.	MoH/TWG		
	1.2.2 Undertake regular training to build external maintenance contracts for key equipment.	• Organize training workshop.	MoH/TWG		
	1.2.3 Develop standard guidelines for equipment maintenance.	• Organize technical working group meetings to develop SOP. • Organize stakeholder validation workshop.	MoH/TWG		
	1.2.4 Capacity building for biomedical engineers	• Organize training workshop.	MoH/TWG		



1.3 Build and upgrade existing infrastructure for genomic surveillance.	1.3.1 Upgrade sequencing platform to procure advanced versions of sequencing equipment	- Organize technical working group meeting to develop SOP. - Organize stakeholder validation workshop.			
	1.3.2 Expand and or build existing and new laboratories for genomic sequencing.	- Expanding of infrastructural - Procure equipment. - Service contract. - Painting and refurbishment.	MoH/DPs		
	1.3.3 Procure computers and accessories for data analysis	- Computers (large servers) - Internet routers. - Softwares. - Data management accessories.	MoH/DPs		
1.4 Ensure the creation of a sustainable genomic surveillance system.	1.4.1 Ensure collaboration between industry and academia.	Organize stakeholder workshop.	MoH/MoE/MoFA/MESTI		
	1.4.2 Integrate genomic surveillance into IDSR.	- Organize Technical working Group meetings. - Organize stakeholder workshop.			
2.1 Integrate genomic data into the existing electronic surveillance system.	2.1.1 Procure robust data management system and high-capacity storage solutions for genomic data.	Procure Data management accessories.	MoH	Q4/2024	2,150,000
	2.2.2 Train personnel in advanced genomic techniques, bioinformatics, and data analysis.	Organize training workshop.	MoH/DPs/TWG		
	2.2.3. Integrate genomic data with existing public health information systems to enhance its utilization.	- Organize Technical Working Group meetings. - Organize stakeholder validation workshop.	MoH/DPs/TWG		
	2.2.4 Develop protocols for real-time data sharing among relevant stakeholders.	- Organize Technical Working Group meetings. - Organize stakeholder validation workshop.	MoH/DPs/TWG		



2.2 Improve sample management.	2.2.1 Train all stakeholders in sample management	Organize stakeholder validation workshop.	
	2.2.2 Procure sample management consumables	Procure logistics for sample management.	MoH/DPs/TWG
	2.2.3 Improve sample referral networks	Organize coordination meetings.	
	2.2.4 Develop a protocol for representative sampling for pathogens of interest for genomic surveillance.	- Organize Technical Working Group meetings. - Organize stakeholder validation workshop.	MoH/DPs/TWG
3.1 Develop training programs for genomics and bioinformatics.	3.1.1 Organize regular capacity-building programs like workshops, webinar's, on lines courses etc) specialized personnel.	Organize training workshop.	MoH/MoE/ MoFA/MESTI
3.2 Train laboratory scientists, bioinformaticians, and other relevant health workers	3.2.1 Train and certify personnel laboratory scientists, bioinformaticians, and other relevant health workers.	Organize training workshop.	
3.3 Establish a competency assessment program for all trained staff	3.3.1 Establish an EQA programme for genomic sequencing	- Organize Technical Working Group meetings. - Organize stakeholder validation workshop	Q4/2024 150,300
	3.3.2 Conduct regular competency-based assessment for critical staff personnel.	Organize training workshop.	
3.4 Develop training programs on Biosafety and biosecurity	3.4.1 Training of staff in safety measures and other occupational safety hazards.	Organize training workshop.	MoH/DPs/TWG
3.5 Recruit specialized personnel (bioinformatics, epidemiologist, and related technicians).	3.5.1 Conduct skills gap analysis	Procure a consultant	MoH/DPs/TWG



4.1 Strengthen research and innovation for genomic surveillance.	4.1.1 Develop a research agenda to advance research in genomic surveillance.	• Organize technical working group meeting. • Organize stakeholder validation meeting	MoH/MoE/ MoFA/MESTI		
	4.1.2 Establish structures for data ownership and sharing, consent, confidentiality, and international collaboration.	• Organize technical working group meeting. • Organize stakeholder validation meeting			
	4.1.3 Support research for new genomic technologies for efficient and accurate surveillance.	• Organize technical working group meetings (Proposal and concept note development)			
	4.1.4 Advocate for dedicated and adequate funding for genomic research and innovation.	• Organize technical working group meetings (Proposal and concept note development).			
5.1 Establish a governance structure to coordinate genomic surveillance activities	5.1.1 Develop TOR and framework for GSS governance structure.	• Organize GSS TWG meetings to develop a governance framework.	MOH	Q4-2024	200,000
5.2 Develop a framework to support and mobilize resources for genomic surveillance.	5.2.1 Develop a resource mapping framework to mobilize adequate resources for improved genomic surveillance.	• Procure a consultant. • Organize technical working group meetings. • Organize stakeholder validation meetings.	MoH/MoE/ MoFA/MESTI	Q4/2024	400,000
	5.2.2 Implement the framework and ensure equitable resource distribution.	• Organize technical working group meeting. • Organize stakeholder validation meetings.			
	5.2.3 Advocate for funding for genomic sequencing.	• Organize technical working group meetings (Proposal and concept note development).			



5.3 Strengthen Monitoring and Evaluation systems	5.3.1 Develop a monitoring and evaluation system.	- Organize technical working group meetings. - Organize stakeholder validation meetings.	MoH/MoE/ MoFA/MESTI	Q4/2024	100,000
	5.3.2 Constitute a high-level national genomic surveillance Committee.	Organize technical working group meetings.			
	5.3.3 Undertake annual regular supportive supervision monitoring visits.	Conduct Monitoring visits.			
5.4 Improve both domestic and international collaboration and coordination for genomic surveillance.	5.4.1 Establish collaboration between researchers, institutions, and industry to facilitate the exchange of knowledge and resources.	- Organize technical working group meetings. - Organize stakeholder validation meeting		Q4/2024	120,000
	5.4.2 Foster partnership among between public institutions and private entities including biotechnology and pharmaceutical companies for infrastructure support.	- Organize technical working group meetings. - Organize stakeholder validation meeting			
	5.4.3 Establish collaboration and networking with the genomic community at national and international around genomic research.	- Organize technical working group meetings. - Organize stakeholder validation meeting			
5.5 Develop guidelines for sample management for genomic sequencing.	5.5.1 Develop training manuals and guidelines for genomics surveillance.	- Organize technical working group meetings. - Organize stakeholder validation meeting.			
5.6 Develop standards and guidelines for genomic data.	5.6.1 Develop an interoperability database that can store and share data and facilitate collection and information exchange for different research and public health institutions.	- Procure a consultant. - Organize technical working group meeting			
5.7 Strengthen regulation in genomic surveillance.	5.7.1 Revise the Public Health Act to include genomic surveillance				
Total cost					2,940,300

Appendix 3 Monitoring and Evaluation Framework for Implementation of the Strategy

STRATEGY	INDICATOR	BASELINE	TARGET	TIMELINE	MOV	RESPONSIBILITY	
						Lead	Collaborator
Objective 1: Improve access to Infrastructure and Logistics for Genomic Surveillance.							
Improve timely availability of reagents, consumables, and logistics/ for genomic sequencing.	Percentage of facilities reporting stockout of reagents, consumables, and logistics	Not readily available	Reduce to 10%	2028	Logistics report, Site visits, Inventory reports	MoH	Health Service Delivery Agencies
	Percentage of genomic supplies captured in the procurement plan	Not available	Increased to 10%	2028	Procurement plan	MoH	Health Service Delivery Agencies
Improve maintenance of functional equipment.	Equipment downtime	Not available	Reduced to 20% by 2028		Maintenance report	MoH	Health Service Delivery Agencies
	Percent of Planned Preventive Maintenance activities implemented	Not available	85%	2028	PPM report	MoH	Health Service Delivery Agencies
	Percent of staff (Biomedical Engineers, Laboratory Scientists) trained in equipment operation, maintenance, and troubleshooting	Not available	95%	2028	Training reports	MoH	Health Service Delivery Agencies
Build and upgrade existing infrastructure for genomic surveillance.	The number of health facilities expanded and retooled with the capacity to carry out genomic surveillance activities	6	50	2028	Project reports	MoH	Health Service Delivery Agencies
	Number of new health facilities built to carry out genomic surveillance activities	Not available	10?	2028	Project reports	MoH	Health Service Delivery Agencies
	Percentage of budgeted computers and accessories procured.	Not available	50	2025	Procurement reports	MoH	Health Service Delivery Agencies
Ensure the creation of a sustainable and genomic surveillance system	Number of stakeholder engagement on genomic surveillance held	Not available	5 (once a year)	2028	Meeting reports	MoH	Health Service Delivery Agencies





	The extent to which genomic surveillance data is integrated into in IDSR	Not available	Full integration	2028	Surveillance reports	GHS	MoH, Health Service Delivery Agencies
Objective 2: Improve sample management, data capture, storage, analysis, use, and management							
Integrate genomic data into the existing electronic surveillance system.	Genomic Information Management System developed	Not available	Genomic Information Management System developed/procured by 2024	2024	GIMS report	MoH	Health Service Delivery Agencies
	Percentage of staff trained in advanced genomics, bioinformatics, and analytics	33	80%	2028	Training reports	MoH	Health Service Delivery Agencies
Improve sample management.	Turnaround time for sample collection, testing and provision of results)	Not available	72 hrs	2028	Referral/Transport logs	NPHRL	MOH, Health Service Delivery Agencies
	Percentage of staff trained in sample management (collection, storage, transportation)	Not available	80%	2028	Training reports	MOH	Health Service Delivery Agencies
Objective 3: Strengthen human resource capacity for genomic surveillance.							
Develop training programmes for genomics and bioinformatics.	Number of capacity building workshops and seminars organised in genomics and bioinformatics.	Not available	5 (1 per yr)	2028	Training reports	MOH	Health Service Delivery Agencies
	Percentage of health staff participated in genomics and bioinformatics training	Not available	80%	2028	Training reports	MOH	Health Service Delivery Agencies
Train laboratory scientists, bioinformaticians, and other relevant health workers.	Percentage of laboratory staff trained and certified in genomics	Not available	80%	2028	Training reports	MOH	Health Service Delivery Agencies
Establish a competency assessment program for all trained staff.	External Quality Assessment programme in genomic sequencing expanded	2	6	2024	EQA curriculum	MOH	Health Service Delivery Agencies
	Percentage of staff trained in safety measures and other occupational safety hazards	40-50	80%	2028	Training reports	MOH	Health Service Delivery Agencies

Recruit specialized personnel (bioinformaticians, epidemiologists, and related technicians).	Percentage of Bioinformaticians Epidemiologists, and related technicians recruited	40-50	80%	2028	Recruitment report	MOH	MOF, Health Service Delivery Agencies
Objective 4: Strengthen Innovation and Research in genomic							
Strengthen research and innovation for genomic surveillance.	Research agenda in genomic surveillance developed	Not available	Research agenda in genomic surveillance developed by 2025	2025	Research agenda	MOH	Health Service Delivery Agencies
Objective 5: Strengthen Governance in genomic surveillance							
Establish a governance structure to coordinate genomic surveillance activities.	Percentage of earmarked funds allocated for genomic surveillance.	Research funds	10% (of GOG allocation for research)	2026	MOH financial statement	MOH	MOF, Health Service Delivery Agencies
Objective 5: Strengthen Governance in genomic surveillance							
Develop a framework to support and mobilize resources for genomic surveillance.	Governance structure established	Not available	Governance structure established by 2024	2024	Committee Report	MoH	Health Service Delivery Agencies, Academia, Private Sector
Strengthen Monitoring and Evaluation systems	Mapping framework to mobilize resources for genomic surveillance developed	Not available	Mapping framework to mobilize resource for genomic surveillance developed by 2024	2024	Resource mapping framework	MOH	Health Service Delivery Agencies
Improve both domestic and international collaboration and coordination for genomic surveillance.	A genomic surveillance committee established and functional	Not available	The genomic surveillance committee established by 2024 with membership from academia and industry	2024	Committee reports	MOH	Health Service Delivery Agencies, Academia, Private Sector
	Supportive supervisory monitoring visits in genomic surveillance conducted	Not available	5 (one in each year)	2028	Monitoring reports	MOH	Health Service Delivery Agencies, Academia, Private Sector
	A national genomic network established	Not available	National genomic network established by 2024 with membership from relevant agencies	2024	Meeting reports	MOH	Health Service Delivery Agencies, Academia, Private Sector





Develop guidelines for sample management for genomic sequencing.	Guidelines for sample management developed	Not available	Guidelines for sample management developed by 2025.	2025	Sample management guideline	MOH	Health Service Delivery Agencies, Academia, Private Sector
Develop standards and guidelines for genomic data	Standards and guidelines for genomic data developed	Not available	Standards and guidelines for genomic data developed by 2025.	2025	Standards	MOH	Health Service Delivery Agency, Academia, Private Sector
Strengthen regulation in genomic surveillance.	Public Health act amended to include genomic surveillance	Public Health Act 851	Public Health act revised to include genomic surveillance by 2027	2027	Amended Public Health Act	MOH	Health Service Delivery Agency, Academia, Private Sector

Appendix 4 Equipment and Accessories by Facilities

NMIMR	KCCR	NPHRL	WACCBIP	VSD	UHAS	GIDL-KNUST
Gridlon (1)	Illumina Iseq 100 sequencer (2), Iseq 100 (2)	Minlon acquired through the US-CDC funding and an Iseq 100	a MiSeq and a Gridlon.	a Minlon MK1C	MinION mk 1b (3)	MinION (MK1B), Quibitflex Fluorometer, Two CPU (Each with capacity of 4.5 Terabyte, Ram of 16G, GPU of OS type is 64 bit; CPU cores of 16); One CPU with RAM (32G), disc capacity of 6 Terabyte, OS Type 64 bit, CPU cores of 20)
NextSeq 2000 (1)					MinION mk1c (4)	
MiSeq (2),	Quibit 4 fluorometer,				Qubit 4 Fluorometer (1)	
Minlon Knb, and K1c. (2)	SeqStudio genetic analyzer,				Nanodrop One Spectrophotometer (1).	
Illumina platforms workstations (16)	Illumina Miniseq sequencer					
Server (1), CPU cores (144), one terabyte of ram (1), TB of storage (200).	Agilent Tapestation 4150.					
	Two workstations CPUs (Each with capacity of 31G disk capacity, 1 TB CPU and 12 core. A server is also dedicated for additional storage.					



Appendix 5 - List of Contributors/Stakeholders

S/n	Name	Designation/ Organization
Strategic Leadership		
1	Hon. Dr. Bernard Okoe Boye	Minister for Health
2	Hon. Alexander Akwasi Acquah (MP)	Dep. Minister for Health
3	Hon. Adelaide Ntim (MP)	Dep. Minister for Health
4	Alhaji Hafiz Adam	Chief Director, Ministry of Health
5	Dr. Frank John Lule	WHO Country Representative-Ghana
6	Hon. Kwaku Agyeman-Manu (MP)	Immediate past, Minister for Health
7	Hon. Alhaji Mahama Asei Seini (MP)	Immediate past, Dep. Minister for Health
8	Hon. Tina Mensah (MP)	Immediate past, Dep. Minister for Health
9	Prof. Francis Chisaka Kasolo	Immediate past, WHO Country Representative-Ghana
Technical Working Group		
1	Emma Ofori Agyemang (Mrs)	Director, PPME, MoH
2	Prof. William Ampofo	National Vaccine Institute
3	Dr. Baffuor Awuah	Director Technical Coordination, MoH
4	Dr. Ignatius Awinibuno	Director Allied Health Services, MoH
5	Dr. Sally-Ann Ohene	WHO-Ghana
6	Prof. Kofi Bonney	NMIMR, University of Ghana
7	Dr. Prince Asare	NMIMR, University of Ghana
8	Dr. Nana Afia Asante Ntim	NMIMR, University of Ghana
9	Dr. Michael Owusu	KCCR/KNUST
10	Prof. Kwabena Duedu	UHAS, Ho
11	Dr. Guracha Argata Guyo	WHO-Ghana
12	Mr. Christopher Tamal	WHO-Ghana
13	Dr. Bernard Nkrumah	AFENET Ghana (CTR: US CDC)
14	Dr. Theophilus Odoom	VSD/AVL, Ministry of Food and Agriculture
15	Dr. Lucas Amenga-Etego	WACCBIP, University of Ghana
16	Dr. Dennis Laryea	Ghana Health Service
17	Dr. Gifty Boateng	NPHRL-Ghana Health Service
18	Dr. Azumah Abdul-Tawab	PHD-Ghana Health Service
19	Dr. Ernest Konadu Asiedu	NCCRM
20	MLS. William Addo Mills-Pappoe	CLU-ICD-Ghana Health Service
21	Mr. George Kpentey	Korle-Bu Teaching Hospital
22	Dr. Christopher Nkrumah	Christian Health Association of Ghana
23	Mr. Benjamin Nyakutsey	Ministry of Health
24	Mr. Kwakye Kontoh	Ministry of Health
25	Dr. Eric Nsia Boateng	Ministry of Health
26	Dr. Joseph Nii Otoo Dodoo	Ministry of Health
27	Dr. Mavis Sakyi	Ministry of Health
28	Mr. Alex Kpakpo Moffatt Obrempong	Ministry of Health
29	Mr. Lucas Annan	Ministry of Health
30	Ms. Kafui Dansu	Ministry of Health
31	Ms. Zuleiha Aminu Luqman	Ministry of Health
32	Mr. Solomon Laryea	Ministry of Health
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