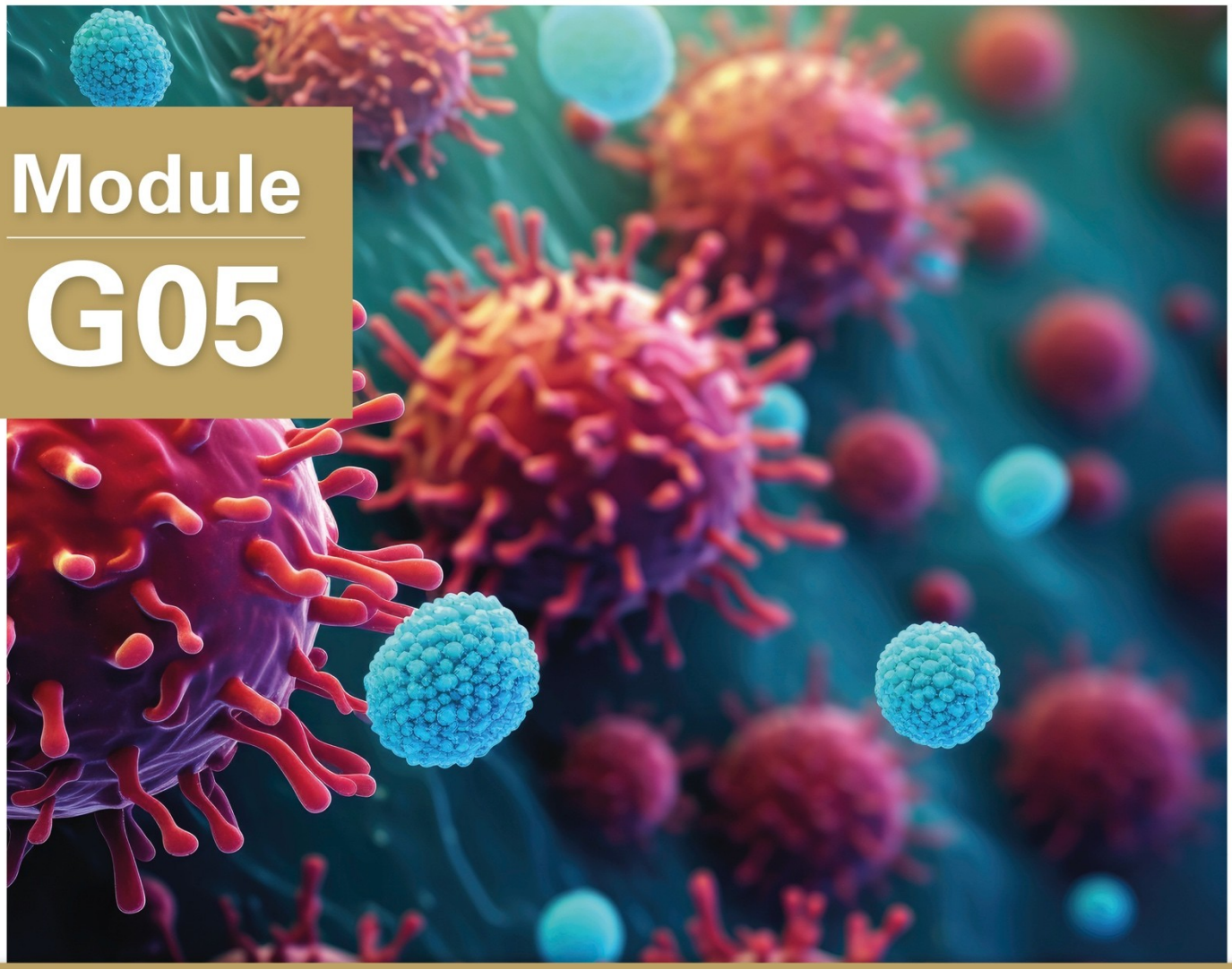
AfricaCDC
Centres for Disease Control and Prevention

Safeguarding Africa's Health



Module G05

Generic Foundational Course

Fundamentals of Pathogen Genomic Surveillance Study Design

NGS Academy for the Africa CDC

ASLM
AFRICAN SOCIETY FOR LABORATORY MEDICINE

H3ABioNet
Pan African Bioinformatics Network for H3Africa

ASLM ACADEMY

Module

G05

Fundamentals of Pathogen Genomic Surveillance Study Design

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Module last updated:
December 2024

Number of sessions	1–2
Total learning time	5–7 hours
Target audience	Target audience: All personas - wet laboratory personnel (i.e., scientists, laboratory technicians, etc.), dry laboratory personnel (epidemiologists, bioinformatics scientists, and bioinformaticians), and managerial personnel (i.e., HODs, laboratory managers, policymakers, etc.).
Format	Lectures, videos
Level of the module	Introductory

Contributors

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Suggested pre-requisite module(s)

- Module G02. Introduction to Traditional, Field, and Genomic Epidemiology
- Module G03. An Overview of the Role of Genomic Epidemiology in Pathogen Genomic
- Module G04. Fundamentals of Biostatistics

Module description

In Module G02., participants were introduced to the basic principles of traditional, field, and genomic epidemiology whereas in Module G04., the fundamental principles of biostatistics and the key concepts of conventional study design were discussed. In this current module, participants are introduced to the key principles of study design as it specifically relates to pathogen genomic surveillance. The application of field epidemiology study design principles in the study design of pathogen genomic surveillance is also explored. Furthermore, some of the common models considered in the design of different pathogen genomic surveillance investigations are briefly discussed. In this module, participants are introduced to the following topics and/or concepts:

- A revisitation of the basic principles of field epidemiology
- Global burden of infectious diseases
- The One Health Field Epidemiology (COHFE) Framework
- Integration of field epidemiology with pathogen genomic surveillance
- Understanding populations at risk through demographics
- Disease transmission routes and patterns
- Basic susceptible-infected-recovered (SIR) models and interventions
- Adaptations for non-directly transmitted and diverse pathogens
- Key components of pathogen genomic surveillance study design
- Different types of pathogen genomic surveillance study designs
- Sampling approaches for:
  - Disease outbreak investigations
  - Baseline data collection
  - Large-scale outbreak investigations
- Types of epidemiological models:
  - Structural causal models
  - Multivariable models
  - Individual-based models
- Sampling design in genomic epidemiology studies
- Model fitting and parameter estimation
- Applications in health policy decision-making
- Global genomic surveillance strategies
- National surveillance action plans
- Outbreak detection and response systems
- Planning and methods for epidemiological analyses
- Causal inference principles and applications
- Epidemiological inference from genomic data
- Phylodynamic models and applications
- Metagenomic data analysis
- Application of pathogen surveillance data in outbreak detection and response
- Integration of field epidemiology and pathogen genomic surveillance methods
- Cross-disciplinary applications in bioinformatics
- Translation of surveillance evidence into public health action

Module learning outcomes

On completion of this module, participants will have a basic knowledge of, or will be able to:

- Explain how field epidemiology, genomic epidemiology, and pathogen genomic surveillance intersect in modern public health practice
- Describe the One Health Field Epidemiology (COHFE) Framework
- Differentiate between disease prevalence, incidence, endemics, and epidemics
- Design genomic surveillance studies incorporating essential components
- Differentiate between passive, active, sentinel, and population-based surveillance
- Apply fundamental sampling principles, including:
  - Sample size determination
  - Selection strategies
  - Quality criteria
  - Acceptance/rejection parameters
- Evaluate appropriate sampling approaches for:
  - Outbreak investigations
  - Baseline surveillance
  - Large-scale epidemiological studies
- Explain and apply key epidemiological models:
  - Basic reproduction number (R0)
  - SIR models and their variations
  - Structural causal models
  - Phylodynamic models
- Explain the concept of causal inference and apply the principles of causal reasoning
- Apply causal inference principles to:
  - GWAS studies
  - Survival analyses
  - Metagenomic data
- Evaluate surveillance strategies at:
  - National level
  - Global level
  - For pandemic/epidemic pathogens
- Assess:
  - Outbreak detection systems
  - Response protocols
  - Data integration methods
- Evaluate surveillance programs considering:
  - Infrastructure requirements
  - Storage options
  - Security concerns
  - Instrumentation needs
- Apply basic epidemiological principles across:
  - Bioinformatics
  - Public health policy
  - Disease control programs

- Evaluate:
  - Basic epidemiological data
  - Surveillance outcomes
  - Intervention effectiveness

Module assessments

Module practical: Not applicable
Module quiz: Assessment questions available on the ASLM platform

Module resources

- US CDC | Defining Field Epidemiology | Epidemic Intelligence Service
- NIH | NLM Article - Field Epidemiology: Fit for the future
- WHO | Competencies for One Health Field Epidemiology (COHFE) Framework
- NGS Academy for the Africa CDC PGI | Video - Sampling design in genomic epidemiology studies
- Chapter 4 - Sample selection | An applied genomic epidemiological handbook
- CellPress | Article - Sample size calculations for pathogen variant surveillance in the presence of biological and systematic biases
- NIH | NLM Article - Guiding the design of SARS-CoV-2 genomic surveillance by estimating the resolution of outbreak detection
- WHO | Principles and steps of an outbreak investigation
- Eurosurveillance Article - The case-cohort design in outbreak investigations
- US CDC | Designing and Conducting Analytic Studies in the Field
- NIH | NLM Article - Outbreak Investigations
- US CDC | Analyzing and Interpreting Data from Field Investigations
- Harvard T.H. Chan Videos - Introduction to Infectious Disease Dynamics
  - Infectious Disease Models: Part I
  - Infectious Disease Models: Part II
  - Model Fitting and Parameter Estimation
  - Non-Directly Transmitted and Genetically Diverse Pathogens
- University College London and University of York Video - An introduction to individual-based models in epidemiology, and to inform health policy
- Building and Understanding Individual Based Models to Inform Health Policy
- Oxford Mathematics Video - How do mathematicians model infectious disease outbreaks?
- WHO | International Pathogen Surveillance Network (IPSN)
- NIH | NLM Article - Epidemiological inference from pathogen genomes: A review of phylodynamic models and applications
- GitHub - EpiForBioWorkshop2020
- GitHub - SIB Swiss Institute of Bioinformatics | Training Collection
- Bioconductor GitHub - BiocWorkshops2019: Epidemiology for Bioinformaticians

References

- OpenAI. (2024). Gemini response on learning objectives for fundamentals of pathogen genomic surveillance study design module. Retrieved July 29, 2024, from Gemini
- OpenAI. (2024). ChatGPT 4o mini response on learning objectives for fundamentals of pathogen genomic surveillance study design module. Retrieved July 29, 2024, from ChatGPT
- OpenAI. (2024). Claude 3.5 Sonnet response on learning objectives for fundamentals of pathogen genomic surveillance study design module. Retrieved July 29, 2024, Claude
- OpenAI. (2024). Copilot response on learning objectives for fundamentals of pathogen genomic surveillance study design module. Retrieved July 29, 2024, from Copilot

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