Module G02

Generic Foundational Course

Introduction to Traditional, Field, and Genomic Epidemiology

NGS Academy for the Africa CDC

Module
G02

Introduction to Traditional, Field, and Genomic Epidemiology

back to the table of modules

Module last updated:
December 2024

Number of sessions	2
Total learning time	8 hours
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

Elizabeth Temiloluwa Akande, Temesgen Endalew, Siddiqah George, Carolina Matos, and Mohammed Ahmed Rameto.

Module description

This module introduces fundamental epidemiological concepts and principles while examining the critical interface between traditional and genomic epidemiology. As genomic surveillance becomes increasingly vital in public health response, the module progresses from basic epidemiological methods to advanced molecular approaches in disease investigation. Participants will briefly explore how genomic epidemiology enhances pathogen surveillance, transmission tracking, and evolutionary analysis, with particular emphasis on real-time applications during public health emergencies. Through an integrated learning approach, the module demonstrates how traditional epidemiological principles complement genomic methods to strengthen modern disease surveillance and outbreak response systems. In this module, participants are introduced to the following topics and/or concepts:

- Key terms and concepts in, and principles of, traditional epidemiology
- The key steps in a traditional epidemiological investigation
- The definition of field epidemiology
- Fundamental concepts in field epidemiology
- The connection of theoretical concepts and principles in traditional epidemiology to practical applications in field epidemiology

- Essential field epidemiology investigation tools, case studies, and methodologies
- The relationship between field and genomic epidemiology
- Fundamental terminology used in genomic epidemiology
- Essential theories and concepts in genomic epidemiology
- The role and value of genomic epidemiology in public health surveillance
- The role of genomic sequence mutations in pathogen evolution
- How pathogen genomic sequences are used to build phylogenetic trees
- How phylogenetic trees are used to trace microbial evolution
- Differences between various trees
- The connection between phylogeny and pathogen transmission
- Molecular clocks and pathogen evolutionary rates
- The overlapping timescales of pathogen evolution and transmission
- Estimating pathogen evolutionary rates from genomic sequence data
- How evolutionary rates of microorganisms are used to infer time trees

⚙️ Module learning outcomes

On completion of this module, the participants will have basic knowledge and skills in, or be able to:
- Define fundamental epidemiological concepts including incidence, prevalence, causation, mortality, and morbidity
- Explain core principles of disease distribution and determinants in populations
- Discuss measures of association in terms of relative risk and odds ratio
- Explain the concept of study design in terms of observational vs. experimental studies
- Compare different epidemiological study designs (cohort, case-control, cross-sectional)
- Identify the unique features that distinguish field epidemiology from traditional epidemiological approaches
- Identify and sequence essential steps in epidemiological investigations
- Apply core field investigation principles and rapid response methodologies to outbreak scenarios
- Integrate theoretical principles with field applications and practical investigation strategies
- Evaluate appropriate tools and methodological approaches for field investigations
- Define and accurately use key terminology in molecular epidemiology
- Explain fundamental principles of genomic epidemiology and its role in outbreak understanding
- Evaluate how genomic data and molecular methods enhance public health surveillance
- Explain how genomic mutations influence pathogen evolution and mechanisms of genetic variation
- Explain how pathogen sequence alignments are used to generate phylogenetic trees
- Discuss the differences between phylogenetic, transmission, divergence, and time trees
- Explain the concept of molecular clocks and apply the theory to pathogen evolution
- Analyse how evolutionary and transmission timescales overlap
- Interpret temporal information from phylogenetic analyses

Module assessments

Module practical: Not applicable
Module quiz: Assessment questions available on the [ASLM platform](#)

Module resources

- [MSD Veterinary Manual - Basic Principles of Epidemiology](#)
- [US CDC Manual - Principles of Epidemiology in Public Health Practice (3rd edition)](#)
- [US CDC Manual - Principles of Epidemiology (2nd edition)](#)
- [WHO: Principles and steps of an outbreak investigation](#)
- [The US CDC Field Epidemiology Manual](#)
  - [Defining Field Epidemiology](#)
  - [Conducting a Field Investigation](#)
  - [Manual Chapter/Resources](#)
- [TEPHINET Library](#)
  - [Case Studies in Field Epidemiology: EMR Context](#)
- [ECDC Field Epidemiology Manual](#)
- [FAO | Developing field epidemiology training for veterinarians: Technical guidelines and core competencies](#)
- [US CDC Field Epidemiology Training Program (FETP)](#)
- [OpenWHO | Integrated Disease Surveillance and Response (IDSR)](#)
- [ECDC | Evidence-based methodologies for public health](#)
- [Eastern Mediterranean Public Health Network (EMPHNET) Resources](#)
- [WHO | Genomics in Field Epidemiology](#)
- [RKI | Integrated Genomic Surveillance (IGS)](#)
- [PHG Foundation | Pathogen genomics into practice](#)
- [NIH | NLM Article - Advanced glossary on genetic epidemiology](#)
- [US CDC COVID-19 Genomic Epidemiology Toolkit | Overview](#)
  - [Video - Introduction](#)
  - [Video - What is genomic epidemiology?](#)
  - [Notes - Introduction to Epidemiology](#)
- [NGS Academy for the Africa CDC PGI | Training Materials](#)
  - [FIC|NIH & JHU Video: Introduction to Genomic Epidemiology](#)
  - [Video - Foundations of genomic epidemiology: mutations, substitutions, and genetic divergence trees](#)
  - [Chapter 3: Fundamental theory in genomic epidemiology | An applied genomic epidemiological handbook](#)
- [NIH|NLM Article - Fundamentals of genomic epidemiology, lessons learned from the coronavirus disease 2019 (COVID-19) pandemic, and new directions](#)
- [NGS Academy for the Africa CDC PGI | Training Materials](#)
  - [Chapter 2: The value of pathogen genomics in applied epidemiology | An applied genomic epidemiological handbook](#)

- [US CDC Video - Using Genomic Epidemiology to Advance Public Health Action](#)
- [CZ GEN EPI Modules: Essential Background Theory for Genomic Epidemiology](#)
  - [Webpage - The overlapping timescales of pathogen evolution and transmission](#)
  - [Video - The overlapping timescales of pathogen evolution and transmission](#)
  - [Webpage - From sequences to trees](#)
  - [Video - From sequences to trees](#)
  - [Webpage - Shared terminology for describing phylogenetic trees](#)
  - [Video - Shared terminology for describing phylogenetic trees](#)
  - [Webpages - Genomic epi basics: Practice reading phylogenetic trees](#)
- [Nature Education Article - Reading a Phylogenetic Tree](#)
- [CZ GEN EPI User Guides: Building Nextstrain Trees](#)
  - [Webpage - Viewing phylogenetic trees in Nextstrain](#)
  - [Webpage - Understanding phylogenetic tree types](#)
- [Nextstrain Webpage - How to interpret phylogenetic trees (narrative)](#)
- [CZ GEN EPI Learning Center - Practicing Gaining Epidemiological Insights from Genomic Data](#)
  - [Webpage - Genomic epi basics: Sequence alignments and molecular clocks](#)
  - [Webpage - Estimating evolutionary rates (molecular clocks) from sequence data](#)
  - [Video - Estimating evolutionary rates (molecular clocks) from sequence data](#)
  - [Video - Foundations of genomic epidemiology: Molecular clocks and temporally-resolved trees](#)
- [CZ GEN EPI Modules: Essential Background Theory for Genomic Epidemiology](#)
  - [Webpage - Interpreting and working with evolutionary rates](#)
  - [Video - Interpreting and working with evolutionary rates](#)
  - [Video - Foundations of genomic epidemiology: Phylogeography and trait reconstruction on trees](#)

References

- OpenAI. (2024). Gemini response on learning objectives for an introduction to traditional, field, and genomic epidemiology module. Retrieved July 29, 2024, from Gemini
- OpenAI. (2024). ChatGPT 4o mini response on learning objectives for an introduction to traditional, field, and genomic epidemiology module. Retrieved July 29, 2024, from ChatGPT
- OpenAI. (2024). Claude 3.5 Sonnet response on learning objectives for an introduction to traditional, field, and genomic epidemiology module. Retrieved July 29, 2024, from Claude
- OpenAI. (2024). ChatGPT 4o mini response on shortening or rephrasing the module overview (of G02) to 2 sentences but keeping an academic tone. Retrieved November 18, 2024, from ChatGPT

Acknowledgements