DEPARTMENT OF EPIDEMIOLOGY, BIOSTATISTICS AND EVIDENCE-BASED MEDICINE

AL-FARABI KAZAKH NATIONAL UNIVERSITY
FACULTY OF MEDICINE AND HEALTHCARE

SHORT SUMMARY OF LECTURES ON DISCIPLINE EPIDEMIOLOGY
5 credits

COMPOSER:
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SHORT SUMMARY OF LECTURES ON BASIC EPIDEMIOLOGY

L.1. Introduction to Epidemiology
Epidemiology is the foundational science of public health, studying the distribution and determinants of health-related states or events in specified populations. Its primary aim is to apply this knowledge to control health problems. The field examines patterns of disease by analyzing person, place, and time. Epidemiologists play a key role in disease surveillance, outbreak investigation, and evaluating public health interventions. Ultimately, it provides the essential data and methods for evidence-based health decision-making.

L.2. History and Evolution of Epidemiology
Epidemiology's roots trace back to Hippocrates' observations on environment and health, but it emerged as a formal science in the 19th century. Key milestones include John Snow's 1854 investigation of the London cholera outbreak, which identified a contaminated water pump. The 20th century saw a shift from battling infectious diseases to studying chronic conditions, exemplified by the Framingham Heart Study. Advancements in statistical methods and computing significantly expanded analytical capabilities. Today, epidemiology continues to evolve, integrating molecular biology and addressing global health challenges.

L.3. Concepts of Causation & Epidemiological Triad
Establishing causation, beyond mere association, is a core challenge in epidemiology. Models like Hill's criteria (e.g., strength, consistency, temporality) help evaluate potential cause-effect relationships. The traditional Epidemiological Triad model explains disease occurrence through the interaction of an external **Agent**, a susceptible **Host**, and an environmental **Context**. This model is particularly useful for infectious diseases. For non-communicable diseases, the triad is often adapted, viewing "agent" as a behavioral, chemical, or physical risk factor within a broader ecological framework.

L.4. Summarize and Display Public Health Data
Effective data summarization and display are crucial for communicating public health information. Data types include categorical (counts, proportions) and

continuous (means, ranges). Summary measures like rates, ratios, and proportions condense information for comparison. Visual displays such as tables, graphs (e.g., line lists, bar charts, epidemic curves), and maps (e.g., spot maps) reveal patterns in person, place, and time. Choosing the right format is key to accurate interpretation and informing public health action.

L.5. Measures of Disease Frequency & Data Sources
Measures of disease frequency quantify the occurrence of illness in a population. Key measures include **incidence** (new cases in a time period) and **prevalence** (all existing cases at a point/period in time). These are expressed as rates, proportions, or ratios (e.g., attack rate, mortality rate). Data sources are diverse, including vital statistics (birth/death records), disease registries (e.g., cancer), health surveys (e.g., NHANES), clinical records, and administrative databases. The quality and suitability of the source directly impact the validity of epidemiological analysis.

L.6. Compare Disease Frequency & Standardization
Comparing disease frequencies between groups (e.g., different ages, occupations) is essential for identifying risk factors. Crude rates (overall rates) can be misleading if the groups have different underlying age structures, as age is a strong determinant of disease risk. **Standardization** (age-adjustment) is a statistical technique that removes the distorting effect of different age distributions, allowing for fair comparisons. The two main methods are **direct standardization** (applying a standard population's structure) and **indirect standardization** (producing a standardized mortality/morbidity ratio, SMR/SIR). This process is critical for accurate surveillance and planning.

L.7. Public Health Surveillance
Public health surveillance is the ongoing, systematic collection, analysis, interpretation, and dissemination of health data. Its purpose is to monitor disease trends, detect outbreaks, guide public health policy, and evaluate interventions. **Passive surveillance** relies on routine reports from healthcare providers, while **active surveillance** involves health agencies proactively seeking out cases. The surveillance cycle involves data collection, analysis, interpretation, and dissemination of findings to those who need to know. Effective surveillance is the cornerstone of timely public health response and prevention.

L.8. Design of Epidemiological Studies
Study design is the blueprint for how an epidemiological investigation is conducted to answer a specific research question. The main types are categorized as **observational** (researcher does not intervene) or **experimental** (researcher assigns an intervention). Key considerations include the directionality of inquiry (cohort vs. case-control studies), timing (prospective vs. retrospective), and the unit of observation (individual vs. group). The choice of design involves trade-offs between validity, feasibility, cost, and ethical constraints. A well-chosen design minimizes bias and confounding to yield credible results.

L.9. Observational Analytic Studies
Observational analytic studies identify and quantify associations between exposures and outcomes without intervention. In a **cohort study**, groups are defined by exposure status (e.g., smokers vs. non-smokers) and followed over time to compare outcome incidence; it measures relative risk. In a **case-control study**, groups are defined by outcome status (cases vs. controls), and past exposure is compared; it measures odds ratio. Cross-sectional studies provide a "snapshot" of exposure and outcome prevalence at a single time point. These designs are powerful for studying etiology but are susceptible to confounding and bias.

L.10. Experimental Studies
Experimental studies (clinical trials) are the gold standard for establishing causation, as the investigator actively manipulates the exposure (intervention). Participants are randomly allocated to intervention or control groups to minimize confounding (**randomization**). **Blinding** (masking) of participants and/or investigators reduces bias in outcome assessment. The most rigorous design is the **Randomized Controlled Trial (RCT)**. While providing strong evidence, RCTs can be expensive, time-consuming, and are not always ethical or feasible for certain public health questions.

L.11. Diagnostic and Screening Tests
Diagnostic tests confirm or rule out disease in symptomatic individuals, while screening tests detect potential disease in asymptomatic, apparently healthy populations. Test performance is evaluated by its **validity**: **sensitivity** (ability to identify true positives) and **specificity** (ability to identify true negatives). **Predictive**

values (positive and negative) indicate the probability of disease given a test result and depend on disease prevalence in the tested population. Screening programs must be justifiable based on disease severity, available treatment, and cost-effectiveness. All tests involve trade-offs between false positives and false negatives.

L.12. Basics of Epidemiology of Infectious Diseases
Infectious disease epidemiology focuses on the dynamic interplay between pathogen, host, and environment in disease transmission. Key concepts include the **chain of infection** (reservoir, portal of exit/entry, mode of transmission, susceptible host) and **reproductive number (R0)**, which measures transmission potential. Modes of transmission are classified as direct (person-to-person) or indirect (via vectors, vehicles, air). Herd immunity, achieved through vaccination or prior infection, protects populations by reducing transmission opportunities. Understanding these dynamics is critical for outbreak control and prevention.

L.13. Epidemiology of Non-communicable Diseases
NCD epidemiology focuses on chronic diseases (e.g., heart disease, cancer, diabetes) not transmitted between people. These diseases have complex, multifactorial etiologies involving genetic, behavioral (e.g., smoking, diet), and environmental risk factors. Study designs often involve long-term cohort studies to identify risk factors and measure incidence. The burden of NCDs is rising globally, creating a "dual burden" with infectious diseases in many countries. Prevention strategies emphasize primary prevention (reducing risk factors) and early detection through screening.

L.14. Outbreak Investigation
Outbreak investigation is a core function of field epidemiology to control ongoing illness and prevent future outbreaks. It follows a systematic sequence: 1) Confirm the outbreak and diagnosis, 2) Define cases and conduct active case finding, 3) Tabulate and orient data by person, place, and time, 4) Generate and test hypotheses (often via analytical studies), and 5) Implement control measures and communicate findings. The process is iterative, with control measures often implemented early based on initial evidence. A final report summarizes the investigation for public health learning.

L.15. Preventive and Prophylaxis Methods
Prevention in epidemiology operates at three levels: **primary** (preventing disease

onset, e.g., vaccination, health promotion), **secondary** (early detection and treatment to halt progression, e.g., screening), and **tertiary** (managing established disease to prevent disability, e.g., rehabilitation). **Prophylaxis** refers to specific measures to prevent disease, such as antimicrobial prophylaxis or pre-exposure vaccination. Strategies can be **population-based** (aimed at the whole population) or **high-risk** (targeting susceptible individuals). The choice of strategy depends on the disease, available resources, and the principles of effectiveness and efficiency.