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1.0 Introduction to Epidemiology

Epidemiology is the study of the distribution and determinants of health-related states, or events in a specified population, and the application of the knowledge thereof to control health problems. It can also be defined as the science of understanding causes of disease in different groups of people and how to mitigate it. Epidemiology examines the frequency and patterns of health events in populations, looking at who is affected, locations of affected individuals, and the time of disease occurrence. Epidemiology also investigates factors that influence health ie biological, behavioural, social, and environmental factors. The study of epidemiology also examines how groups and population are affected by health events. (Health, 2020)

Finding from epidemiological studies are used to develop and implement strategies for disease prevention and control, as well as provide guidance for health system strengthening.

1.1 Historical Overview of Epidemiology

The study of epidemiology has had its roots stretching way back to ancient times, however, its modern form emerged in the 19th century. The works of Hippocrates and John Graunt laid the groundwork for epidemiology, while the likes of John Snow are with its more scientific development. (CDC, 2023)

Historical development of epidemiology can be divided into the following eras;

- Ancient Greece – where the works of Hippocrates takes more precedence, Hippocrates, often called the father of Medicine. He studied the influence of environmental factors and factors on disease, where he

suggested are rational cause of illnesses, rather than supernatural causes. He surmised that environmental and host factors such as behaviours might influence the development of diseases

- 17th Century – this era showcased the works of John Graunt, an English Statistician. He analysed mortality data, quantifying patterns of birth, death, and disease occurrence, noting disparities and variations between males and females, high infant mortality, urban/rural differences, and seasonal variation

- 18th century – during this time, William Farr built on the works of John Graunt. He systemically collected and analysed Britain's mortality statistics. His work earned him the name, Father of modern vital statistics and surveillance. He developed many of the basic practices used today in vital statistics and disease classification

- 19th Century – this era outlined the works of John Snow, where he identified the cause of cholera outbreak. He demonstrated the link between contaminated water and disease transmission, which eventually served as a key event in the history of public health and epidemiology.

- Early 20th Century – this time saw the introduction of mathematical and statistical methods in analysing epidemiological data. It also saw the strengthening of evidence base for epidemiological findings. The works of Ronald Ross, Anderson Gray McKendrick, and other cannot be ignored. Finally, the publication of result of British Doctors study, led by Richard

Doll and Austin Bradford Hill, which lent a very strong statistical correlation that tobacco smoking has link to lung cancer.

1.2 Scope of Epidemiology

Epidemiology encompasses the study of the distribution and determinants of health-related states or events in specified populations, the application of this study to the control of health problems. It does not only limit to investigation of diseases but also other health related events, such as injuries, disabilities, and health services utilisation.

The core activities of epidemiology can be classified as follows;

- Describing health events
- Identifying determinants of health
- Controlling health problems

The field of epidemiology focus on understanding distribution, determinant, and controlling health events that are linked to **Infectious diseases and Chronic diseases.** It is also applied to evaluate effectiveness and efficiency of health care service delivery and interventions. The impact of environmental factors, such as air and water quality, exposure to toxins, on health are also investigated using epidemiological studies. Social epidemiology and Clinical epidemiology are other areas that benefits greatly from the principle of epidemiology.

The scope of epidemiology is so wide that it encompasses almost every field that covers health related states and events, hence, the impact of epidemiology in global health cannot be overemphasised.

1.3 Epidemiology in Public Health

Epidemiology is a core science in public health, it provides basic evidence for public health interventions and policies. Epidemiologist – experts in epidemiology, investigates the causes of diseases, patterns of outbreaks, and how these conditions impact individuals and communities, with the goal of preventing and controlling health problems.

The role of epidemiology in public health can be categorised into the following headings;

- *Epidemiology as a tool to understanding disease distribution and determinants*:
    - Distribution: epidemiology examines “who” (person), “when” (time), and “where” (place) health related events occur within a specified population
    - Determinants: it helps to understand the factors that influence the occurrence of health events, which includes, biological, environmental, social, and behavioural.
- *Core function of epidemiology in public health*
    - Disease Surveillance: the knowledge of epidemiology helps to monitor disease patterns to detect outbreaks and track trends, which used to determine appropriate health response

- Outbreak investigation: it is used to investigate the causes and spread of infectious diseases to control outbreak and prevent future occurrences.
- Evaluation: epidemiology evaluates the effectiveness of public health interventions and programs
- Risk assessment: epidemiology in public health is used to identify the population at high risk for specific diseases and develop targeted prevention strategies

➢ *Application of epidemiology in public health:*

- Policy formulation: epidemiological data is important for developing evidence – based public health policies and regulations
- Resource allocation: resource allocation are prioritised, where interventions are channel to area with high disease burden and risk factors
- Health promotion: epidemiology provides basis for health promotion campaigns and interventions aimed at preventing diseases and promoting healthy behaviours.
- Clinical practice: the knowledge of epidemiology is used for developing clinical guidelines and treatment protocols

2.0 **Basic Epidemiological Concepts**

Epidemiology is a quantitative discipline built on the knowledge of probability, statistics, and sound research methods. Methods of causal reasoning based on developing and testing of hypotheses pertaining to occurrence and prevention of morbidity and mortality. It is a tool for public health action to promote and protect the public's health based on science, causal reasoning, and of practical common sense. (Cates, 1982)

2.1 **Measure of Disease Frequency**

Measure of disease frequency are used in epidemiology to quantify how often a disease or health event occurs in a population. There 2 main measure of disease frequency in epidemiology, and they are; **Prevalence** and **Incidence.**

- **Prevalence**: this is used to measure the proportion of individuals in a population who have a disease at a specific point in time, or over a specified period. It is useful for understanding the burden of disease in a population and for planning healthcare resources. Prevalence can be calculated by the formular below;

  P = No of existing cases / Total population

- **Incidence**: this is the measure of the rate at which new cases of a disease develop in a population at risk during a specified period. It is used to study the causes of disease and for evaluating the effectiveness of prevention programs. There are two (2) common measures of Incidence, namely; Risk – Cumulative Incidence, it gives insight on the proportion of initially disease – free individuals who develop the disease during a specified time

period. While, Rate – Incidence Rate, provides information on the number of new cases per unit time, taking into account the time each individual is at risk.

In general, Prevalence and Incidence provides information on how much a disease exist, and the number of new cases of the disease occurring respectively.

2.2 **Measure of Association**

Measures of association in epidemiology is used to quantify the relationship between an exposure (Risk factors) and an outcome (disease). They are used to understand how strongly an exposure is linked to a health outcome and if the link suggests a causal relationship. Common measures of association are; **relative risk, odds ratio**, and **risk difference** etc.

- *Relative Risk (RR) or Risk Ration*: this compares the risk of an event in an exposed group to the risk in an unexposed group. A RR of 1 indicates no association, a RR greater than 1 indicates increased risk, while a RR less than 1 indicates decreased risk in the exposed group

- *Odds Ratio (OR):* this compares the odds of an outcome occurring given a particular exposure to the odds of the outcome occurring in the absence of that exposure. OR is usually used in case-control studies, where it can be a good approximation of the RR, especially when the outcome is rare.

- *Risk Difference (Attributable Risk):* this quantifies the absolute difference in risk between two groups. For example, if the risk of heart related disease is 10% in group exposed to a high-fat diet and 5% in a group with low-fat diet, the risk difference is 5%. This risk difference tells how much excess risk attributable to the exposure.

- *Rate Ratio:* it is similar to RR, but it compares Incidence rates of an event in different groups. This is usually used in cohort studies.

Understanding these measures of association as well as their limitations is very important in interpreting epidemiological studies and drawing valid conclusions about health outcomes.

2.3 **Types of Epidemiological Studies**

Epidemiological studies are broadly classified into observational and experimental types. Observational studies are either descriptive or analytical, and they focus on observing and analysing existing data without intervention. While experimental studies – interventional studies, are classified into Randomised Control Trials (RCT), or Clinical trial, and non randomised Quasi – Experimental field Trial. While observational studies are either descriptive or analytical, they can be population or individual based studies. population based descriptive studies, are usually health survey, while population analytical studies are ecological research. (Gordis, 2014)

On the other hand, individual based observational studies are, case report and case series, which are descriptive in nature, while cross-sectional study (prevalence study), case-control study and cohort study, are analytical.

In observational descriptive studies, the aim is to describe the distribution of disease or health-related invent in terms of person, place, and time. They are usually used to generate hypothesis (Rothman, 2008). In analytial studies, the aim is to investigate relationship between exposure and outcome, while testing generated hypothesis.

Experimental studies, are classified into three main categories naamely;

- Randomised Control Trials (RCTs): This is considered as the gold standard of study design. In RCT, the researcher randomly assignes the subjects to a control group and an experimental group. The use of randomization is to avoid confounding and minimize selection bias. The experimental group gets the exposure/treatment, which are usually causative agents, prevention, or treatment of disease. The control group receives no treatment, a placebo treatment depending on the study's objective. The groups are then observed to see who develops the outcome of interest. However, researchers adopting RCTs as study design often face issues with integrity of randomization due to refusals, dropouts, crossovers, and non-compliance. (Swapna Munnangi, 2023)
- Field Trials: this are research study conducted "on the ground" in real-world settings, rather than in coontrolled clinical environment. These trials

are used in evaluating the effectiveness of preventing or therapeutic interventions in populations that are not confined to a hospital. The study usually involves assessing the role of interventions in risk reduction of healthy individuals who are at risk of developing a disease. (Smith P. G, 2015)

- Community Trial: this is a field trial a whole population (communities). Community trials focuses on mass education campaigns aimed at changing people's knowledge and attitude. The intervention of interest is given to the subjects eg vector control measures to reduce Malaria, provision of pit latrine to prevent open defeacation which could lead to cholera or other oral-feacal diseases.

3.0 **Epidemiological Data Sources and Measurement**

Epidemiological data sources are varied, they include, routinely collected vital statistics and health service records to specialised surveys and disease registries. Where as measurement in epidemiology involves quantifying health events (incidence and prevalence), identifying associations between exposure and outcomes, and assessing the impact of interventions.

- *Data Sources:* Data sources in epidemiology are either Primary or Secondary.

  Primary data sources are;

  - Census: provide a information of the entire population at a specific point in time
  - Surveys: gather information from individuals about their health behaviours, experience, and exposures
  - Interviews and observations: detailed information are collected through direct interaction with individuals or by observing specific behaviour or events
  - Experiments: factors are manipulated to study their effects on health outcomes

Secondary data sources;

- Vital statistics: this are records of births, deaths, and other vital events, which are important in tracking disease pattern and mortality rate
- Health service records: they are data abstracted from hospitals, clinics, and other healthcare providers, including patients records, disease registries, and insurance claims
- Disease registries. These are dedicated systems for collecting information on specific diseases, such cancer or birth defect
- Public health surveillance system: these are depository data generated during ongoing monitoring of disease occurrence and other health events
- Morbidity reports: these are data on the prevalence and incidence of diseases, often collected through mandatory reporting systems

3.1 **Vital Statistics and Surveillance Systems**

Vital statistics in public health are very important data set, which involves births, deaths, marriages, and other significant life events within a population. These statistics are vital for understanding trend of population health, identifying disease patterns, and informing public health interventions. They are the basis for understanding population dynamics and health status.

Historically, collection of vital statistics dates back to the 17th century, it was popularised by John Graunt – an English statistician. During the time, Graunt analysed mortality data from outbreaks in London, and from then onward the field

evolved significantly, with advances in data collection, analysis and interpretation.

The development of vital statistics has been shaped by various factors, including:

- Improvements in data collection methods and technologies
- Changes in population demographics and health trends
- Advances in statistical analysis and epidemiological methods
- Increased recognition of the importance of vital statistics in public health decision-making

Vital statistics are very important and play a critical role in public health decision-making by providing essential data for:

- Identifying health priorities and setting policy agendas
- Developing targeted interventions and programs
- Evaluating the effectiveness of health initiatives
- Informing resource allocation and budgeting decisions

Vital statistics data are sourced through access to the following data depository:

- Census data: collected through national censuses
- Surveys: these are usually household surveys, health surveys, and other types of surveys
- Administrative records: these are data obtained from government agencies, hospitals, and other healthcare providers.

Surveillance System: surveillance is the ongoing and systematic collection, analysis, and interpretation of health data to monitor disease trends, detect outbreaks, and guide

public health interventions. Its a continuous process that aims to understand disease patterns, predict potential health threats, and ultimately improve population health.

There are three main types of surveillance systems, namely:

- Passive Surveillance: this involves regular, ongoing reporting of diseases and conditions by all health facilities in a given population
- Active Surveillance: an active surveillance system is one where health facilities are visited and healthcare providers and medical records are reviewed in order to identify a specific disease or condition (WHO, Surveillance for Preventable Diseases, 2014)
- Syndromic surveillance: this is the continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice. (WHO, 2016)

3.2 **Surveys and Population Based Studies**

Population-based surveys are research studies that collect data from a representative sample of a specific population with the aim of understanding their characteristics, health, or overall behaviours of the population. The surveys are vital for monitoring health trends, identifying risk factors, and informing public interventions.

Population-based surveys are characterised by:

- Representative sample: the sample accurately reflects the larger population being studies, which allows for generalization about the population of interest
- Defined Population: the population of interest is clearly defined by geographic location, age group, sex, and other unique parameters of interest

- Data collection Method: various data collection methods are deployed in population-based surveys eg face-to-face interviews, telephone surveys, online questionnaires etc
- Monitoring and Evaluation: they are also used for tracking health trends, evaluating effectiveness of public health behaviours, and access to health.

Common types of population-based survey are; House surveys, World Health Surveys etc. They can be further classified by either research purpose, such as exploratory, descriptive, or explanatory or by sampling method. The sampling methods are:

- Probability sampling – which ensure every individual in the population has a known chance of being selected, allowing for more reliable generalization to the entire population. Probability sampling is further divided into:
  - Simple random sampling
  - Systematic sampling
  - Stratified sampling
  - Cluster sampling
- Non probability sampling is another sampling technique, which relies on specific criteria or convenience for selecting participants. They are:
  - Convenience sampling
  - Quota sampling
  - Purposive sampling
  - Snowball sampling

4.0 **Infectious Disease Epidemiology**

This is the study of how and why infectious diseases emerge and spread among different populations, and what strategies can be used to prevent or contain the spread of disease at the population level. Infectious disease epidemiology examines the complex interactions between pathogens, hosts, and the environment to determine the dynamics of infection and develop intervention strategies. (Kobayashi, 2004)

Infectious disease epidemiology is very key in public health as its provides more insight in understanding key public health indicators. The following are key aspect of infectious disease epidemiology.

- Study of Disease Occurrence: it investigates the distribution of infectious disease in population over time, including incidence (New Cases) and prevalence (existing cases)
- Causative Agents: it helps in understanding specific infectious agents (bacteria, viruses, parasites etc) responsible for diseases.
- Host-Pathogen interactions: understanding how characteristics of the host and pathogen ie (age, immune status, genetics), and (virulence, transmission route) respectively influence disease development.
- Environmental Factors: it helps in understanding the role physical, social, and behavioural environment plays in disease transmission
- Transmission Dynamics: this entails how pathogens spread through different routes eg direct contact, airborne, vector borne etc
- Developing Intervention Strategies: it is used to develop and evaluate methods to prevent and control spread of diseases, such

as vaccination campaigns, hygiene practices, and public health policies.

- Emerging and re-emerging Diseases: this is a pointer to understanding and responding to new diseases, and those that were previously controlled but are resurfacing.
- One Health Approach: it recognises the interconnectedness of human, animal, and environmental health disease challenges, most importantly Zoonotic diseases.

4.1 **Transmission Dynamics and Outbreaks**

Transmission dynamics is a concept in epidemiology that explores how infectious diseases spread within population. This involve studying the patterns, mechanisms, and factors influencing the transmission of pathogens from one individual to another. Infectious diseases, have caused several epidemics and pandemic in recent years, and have significantly disrupted daily life. During most of these pandemics, public health and social measures (PHSMs) have been used to reduce the burden of these pandemics by reducing their transmissibility and susceptibility in the communities. (Achangwa C., 2022)

In other to reduce the overall burden of infectious disease in a community, it is important to consider the direct and indirect impact of PHSMs on diseases with similar transmission characteristics. Transmission dynamics provides crucial insights into the behavior and spread of infectious diseases. It can also provide helpful information on:

- High-risk population

- Inform public health measures
- Predict and control outbreaks

However, understanding the factors influencing transmission dynamics of infectious diseases is essential for designing effective prevention and control strategies. Below are some key factors:

- Mode of transmission
- Infectious period
- Reproductive number (RO)
- Susceptibility and immunity
- Contact pattern
- Environmental Factors
- Behavior and intervention measures

Outbreak of infectious diseases: A disease outbreak is the occurrence of diseases cases in excess of normal expectancy. The number of cases varies according to the disease-causing agent, and the size and type of previous and existing exposure to the agent.

Disease outbreaks are usually caused by an infection, transmitted through person-to-person contact, animal-to-person contact, or from the environment or other media. They may also occur following exposure to chemicals or to radioactive materials.

4.2 **Epidemic, Pandemic and Endemic in Public Health**

Disease outbreaks can be classified into three main types, namely; Epidemic, Pandemic, and Endemic. Understanding the type of outbreak is very important in public health service delivery. It provides information on the disease type, causative agent, spread, rate of new cases, and containment protocol.

Epidemic: an epidemic outbreak is a disease outbreak which spreads rapidly to a large number of people in a given population over a short period of time. It is not only used for infectious diseases; it can also be used with any condition that leads to a detrimental risk of health risk within a society. Example, the rise in obesity, often referred to "obesity epidemic". When used in infectious diseases, epidemic can be described as sudden rise in cases of new infectious agents, mutations or moving between host population eg from animals to humans (Zoonotic disease).

Pandemic: this is the spread of a transmissible infectious/communicable disease over several continents or worldwide. The term pandemic, is used to describe the rate and distance of spread of the disease and not the severity of the disease. Pandemic outbreaks are characterised by:

- Affects wider geographic area, often global
- Infect high number of persons
- Usually caused by new microorganism, or a new strain of a dormant pathogen
- Spreads quickly in humans as there is little to no existing immunity

- Can cause high number of deaths
- Due to the need to control the spread of the disease, there is often social disruption, unrest and economic loss

Endemic: this a disease condition that is present in a society or country on almost constant level. Each country may have a disease that is unique, for example;

- Dengue, in the Caribbean
- Varicella (Chicken Pox), in the UK among children under the age of 10
- Malaria, In Africa

5.0 **Challenges in Global Health Epidemiology**

Global health epidemiology is bedevilled with numerous challenges, this includes; emergence and re-emergence of infectious diseases, the rise in non-communicable diseases, impact of climate change, and complexities of global health security. In dealing with these challenges, a multi-faceted approach is required. These approaches include; health system strengthening, improving access to healthcare, engendering international collaboration.

5.1 **Key Global Health Challenges:**

The following are key global health challenges that requires internation collaboration for mitigation. However, these challenges were fully captured in the Millenium Development Goals (MDGs), though with minimal impact in developing economies. It has also been integrated in the sustainable development goals (SDGs), which is a follow up to MDGs towards achieving health equity and sustainable development. They key challenges are;

- The emergence and re-emergence of infectious diseases like Ebola, Zika, and COVID-19 highlight the interconnectedness of global health and the need for coordinated responses
- the rise in cases of NCDs, like diabetes, and cardiovascular diseases, especially in low-and middle-income countries is a challenge to reckon with
- Climate Change: the impact of climate change, such as extreme weather conditions, water insecurities, desertification, and flooding exacerbate health inequities and threaten health systems

- Fragile health systems, due to low funding for health, create vulnerability to both infectious disease outbreak and growing burden of chronic diseases
- The rise of Antimicrobial resistant pathogens is threatening the effectiveness of established treatment protocol. This is a serious public health threat
- Poor funding for health: as more diseases are emerging in global health space, so are different health interventions, which are usually expensive. The preventive, diagnosis, and treatment method are technologically driven and expensive. Hence, the need for healthcare financing

5.2 **Addressing Global Health Challenges:**

Global health challenges can be mitigated, and attain equal health for all as enshrined in SDGs 3 & 10 (Good Health & Well-being, and Reduced Inequalities), by:

- Strengthening Health Systems
- Promoting Health Equity
- International Collaboration
- Investing in Research and Innovation
- Strengthening Public Health Capacity
- Raising Awareness and Promoting Prevention
- Addressing the Social Determinants of Health
- Prioritizing Mental Health
- Integrating SDGs in health policies framework

6.0 **Conclusion**

In conclusion, global health and epidemiology share a symbiotic relationship. Epidemiology, which is the study of how disease spread and controlled, provides the data and insight necessary for effective global health initiatives. Understanding the patterns, causes, and effects of health and disease conditions in a defined population is the cornerstone of epidemiology. It is the key to public health interventions that aim to improve global health.

On the other hand, global health, addresses health concerns across borders. It is beyond the perspective of international health and public health by considering the health needs of people living in low and middle-income countries.

Nigeria, as a developing country, and among low and middle-income countries (with multi-dimensional poverty rate of 63% - NBS, 2022), has it own share of health challenges. The NBS report considered four main dimension of poverty ie Health, Education, Living Standards, and Work and Shock. The health component, analysed “nutrition” and “access to healthcare”, and described the country as one of the worst in sub-Saharan Africa for children’s health. It also described access to health financing as unequal, with access and quality healthcare service delivery correlated with wealth. This and other health concerns can be mitigated effectively if epidemiology of diseases are studied with reference to global health, where interventions and policy framework can be developed for healthcare access for all.

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