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Epidemiology: An Interdisciplinary Science for Public Health Assessments

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Abstract: Epidemiology is the study to find out the public health outcomes, diseases in human population and their causes. Epidemiology can also be defined as the scientific, systematic, and data-based study on the distribution patterns of a population and the risk factors and causes of health-related issues. It also includes the events not only the diseases but also other factors affecting health such as pollution, injuries, natural disasters and terrorist activities. In epidemiology global, country, state, city, school, institutions, neighborhood, all types of specified populations are considered and is applicable to all the issues related to public health. In this review we are focusing on the challenges in research layout and evaluation, which makes these studies significant to investigate the various reasons of epidemiology in relation to public health assessment.

Keywords: Epidemiology, Public health, Injuries, Infectious diseases, Non-infectious diseases, Disasters

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Introduction

Epidemiology is one of the important scientific disciplines which directly and clearly describes the phenomenon of occurrence and preventive measures of spread of any disease in human population. The focus of the study is to explain and describe the diseases to the public and public health agencies to apply all the control measures. Epidemiology is one of the oldest branches of science important for public health assessment using records, data collection and analysis on some clinical evidences. It was described by Mervyn Susser in a keynote paper presented in Pan American Epidemiology Congress held at Salvador in April 1995, which was later published (Susser and Susser, 1996). Susser and Susser (1996) described how quantitative epidemiology originated in concern for public health in the mid-17th century and how its application progressed from the study of mass statistics of mortality and morbidity at the beginning of the nineteenth century, through the study of the spread of disease caused by specific infectious organisms, to the study of the behavioral and environmental causes of chronic non-infectious disease, which has

tended to be its principal focus over the last few decades. The public health events which are commonly investigated during the study are environmental exposures, infectious diseases, injuries, non-infectious diseases, natural disasters and some terrorist activities (Fig. 1).

Environmental Exposures:

Every individual supposed to be exposed to the environment and receive the contaminant(s) from different environmental media such as air, water, soil, food through inhalation, skin and ingestion). Environmental epidemiology deals from the public evaluation to environmental management which includes remediation, mitigation, and hazard assessment. In the experimental studies, motive of threat assessment, identification and concentrations of chemicals and other toxicants are investigated. So, the Environmental epidemiology is a speculation-based study to look into specific population or group to reveal the relation between public health with physical, biological and chemical elements of the environment consumed by the individuals in a population (Paustenbach, 2000, 2002; Nieuwenhuijsen, 2003; IGHRC, 2004).

Some evaluation models for environmental exposure are available to estimate the exposure to a particular chemical substance. To estimate airborne contaminants video display units are commonly considered as the most accurate tools. Modern and advanced technologies are available which helps the scientists to measure and collect the data around the clock using transportable and non-invasive methods. Sometimes environmental measurements are done along with the personal statistics of an individual such as ingestion, showering or swimming. This data can be collected through the questionnaire to prepare more specific indices for environmental exposure (Paustenbach *et al.*, 2003; Nieuwenhuijsen, 2003).

The information on environmental exposure contains measures of emission ambient awareness and, microenvironment which is based upon the time spent in the environment. Individual tracking, internal doses and biomarkers also helps in collecting the data. Biomarker record scan is also useful to identify priority exposures, assess effectiveness of danger-mitigation techniques, discover at-danger subpopulations, recognize developments, set up reference degrees and to provide integrated dose measurements.

Biological monitoring has a direct approach of measuring the uptake of hazardous chemical substances and xenobiotics in blood, urine, tissues, hair, sweat or exhaled breath (Paustenbach and Galbraith, 2006).Various biological markers are often used for environmental exposures such as Theaker's of internal dose (blood lead), biologically effective dose (blood DNA, and protein) and markers of biological effects (chromosomal micronuclei). With the various advancements in analytical chemistry, it is now easy to measure the exposure of various chemical compounds. Blood and urine are the most desired media to observe toxicants. In a study conducted in USA, thousands of individuals have been investigated for as many as 256 exceptional chemical compounds in the blood of randomly selected volunteers (http://www.hpa.org.uk/chemicals/biomonitoring.htm).

Biological monitoring strategies can also be an important tool for the assessment of biological or physiological modifications at early stage which are then correlated with the uptake of the hazardous chemical (IGHRC, 2004), which can be an exposure evaluation issue of epidemiology research. Retrospective public health assessments have been proved very beneficial to understand the chemical exposures and lots of epidemiological studies are the need of the hour (Williams and Paustenbach, 2003).

Assessment of environmental exposure is very important part of all the environmental-epidemiologic studies with the help of extensive varieties of exposure-assessment techniques and strategies used in environmental-epidemiological researches. Direct measurements (personal and biologic monitoring and biomarkers) and oblique measurements (micro-environmental monitoring,

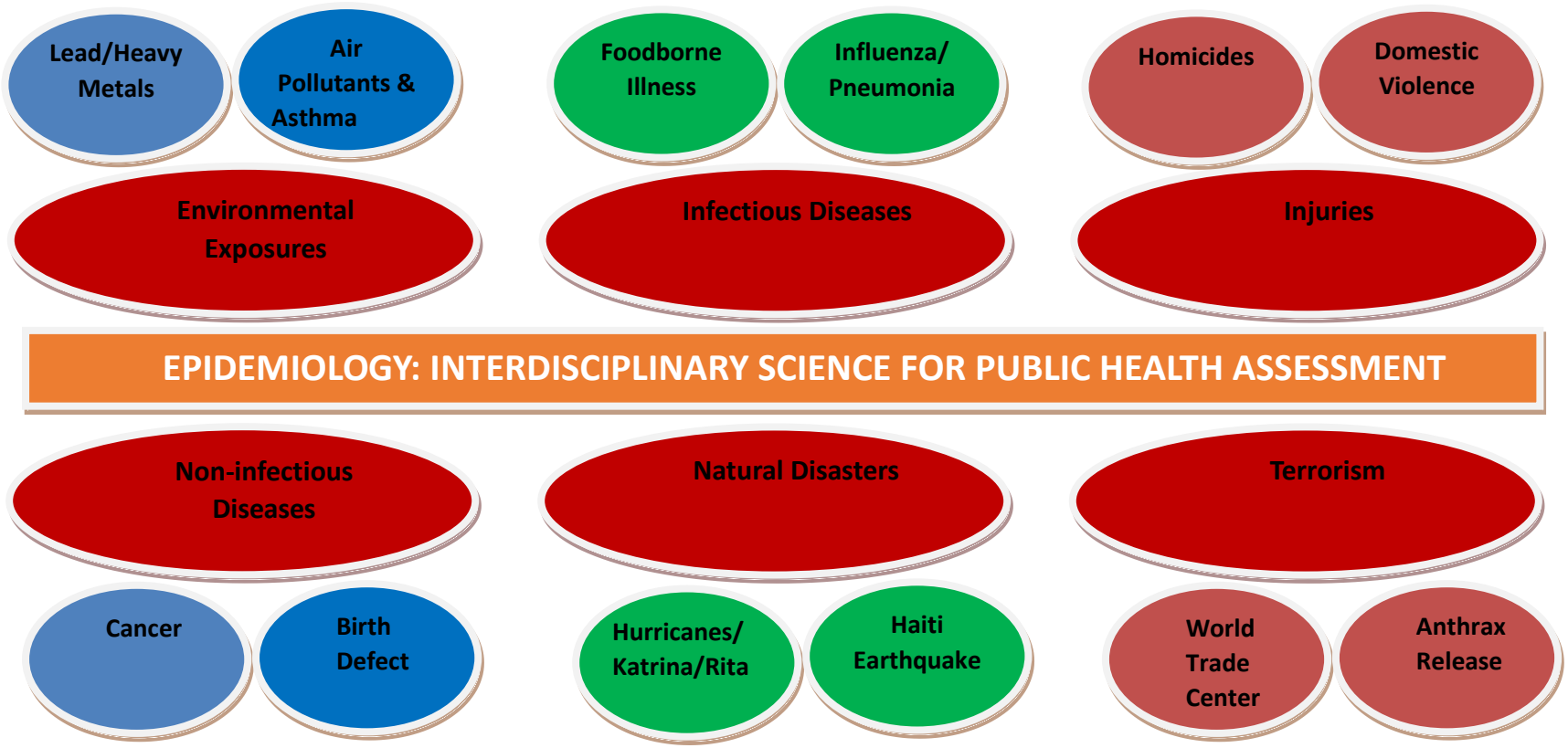

Fig. 1: The public health events which are commonly investigated in Epidemiology for public health assessment.

diaries, and mathematical modeling) can be useful for the evaluation of exposure in environmental epidemiology, that may give more strength to this study.

Infectious Diseases:

Infectious diseases can be defined as the disorders caused by microorganisms such as bacteria, fungi, parasites and viruses. Microorganisms are found everywhere in air, water, soil, on the plants and animal surfaces and inside their bodies. There are two categories of microorganisms viz. harmful and beneficial. But many microorganisms cause various diseases. Any disease is called infectious if it can be transferred from one person to another. There are many other diseases which are transmitted by insects and other animals. Other illnesses may also come from contaminated food, drinking waters and from the exposure to the environment contaminated with microorganisms.

Signs and symptoms may vary depending on the disease-causing organisms, where fever and fatigue are the two most common. Mild infections can be managed through home remedies but the life-threatening infections require hospitalization. Each infectious disease has its specific signs and symptoms, however, there are many which are common to a number of infectious diseases, such as fever, diarrhea, fatigue, muscular pain and coughing. The causal organisms of various infectious diseases can be classified as:

Bacteria: These are prokaryotic unicellular organisms and are responsible for various diseases such as strep throat, urinary tract infection, cholera and tuberculosis etc.

Viruses: Viruses are infectious entities which can multiply only intracellularly and are very infectious than other microorganisms. They are smaller in size than bacteria and cause various mild to severe infections such as ranging from the common cold to AIDS.

Fungi: Fungi are eukaryotic, unicellular or multicellular organisms cause many skin diseases such as ringworm and athlete's foot. Some other species of fungi also causes infections of lungs and nervous system.

Parasites: There are various parasites which lives on or inside our body and cause various diseases such as Malaria which is transmitted by a mosquito when itbites to infected and then to a non-infected person. While other parasites are transmitted to humans and animal wastes. Most of the infectious diseases show only minor complications. But there are some life-threatening diseases such as pneumonia, human immunodeficiency virus (HIV) and meningitis. Some infections can lead to long-term risk of cancers. In addition, some infectious diseases may become dormant, but may reactivate after a certain period of time, Chickenpox is the best example in this category. The infections are usually spread very quickly as the patient does not feel any symptoms when infected with these diseases.

Due to infections various symptoms and complications may occur with the suffered person. Permanent damage to any body's organs and an increase in the risk to other diseases are also common. The infectious diseases can be diagnosed through the advance imaging procedures and laboratory tests. The diseases are mostly symptomatic. Through the sample analysis the microorganisms are identified, it helps the physician in determining the patient's condition. Imaging procedures such as X-rays and CT scans also help in diagnosis of any infection and it rule out the other infections that may be the reason of disease symptoms. Biopsies which are the investigations on tissues from infected body organs or parts further support in reaching any conclusion. Treatment of any infection starts just after the diagnosis of a disease. Knowing the causal organism of the infection, makes it easier to choose the appropriate treatment.

Antibiotics are applied to treat mostly the bacterial infections; as these medicines are ineffective to viral infections. However, sometimes based on symptoms it becomes difficult to find out the causal agent. Pneumonia is the best example

for this as it can be caused by either viruses or bacteria. But the overdoses of antibiotics may lead to the development of resistance to antibiotics in many types of bacteria which makes the treatment more difficult. Some antiviral drugs have also been developed to control some viral infections but not for all types of viruses. Some of the severe viral infections are HIV/AIDS, Herpes, Hepatitis B, Hepatitis C, flu virus and corona virus. Antifungals are used mostly for topical medications for the treatment of skin or nail infections. Some of the fungal infections affecting the lungs or mucous membranes, can be treated with oral antifungal medicines.

In case of more severe fungal infections of internal organs in the patients of weak immune systems, intravenous administration of antifungal drugs can be done. Antiparasitics are used for malaria, and many other internal and external parasites such as nematodes. During the treatment of any infection some supplements such as Vitamin C and D and Zinc are also prescribed to shorten the duration of infection. There are measures to prevent the spread of infectious diseases and many steps can be taken to reduce the risk of infection including cleaning the hands regularly, and receiving all vaccinations on time.It is also important to have safe sex to prevent the transmission of sexually transmitted diseases.

Injuries:

The Centers for Disease Control and Prevention and many other state and local health departments have given high priority to the prevention of intentional and unintentional injuries (Waller, 1987; NCIPC, 1989; Brown *et al.*, 1990; USHHS, 1992). Epidemiologists working in various public health departments and businesses and academicians have a perception that the increasing number of such type of studies on public fitness methods can decrease injury morbidity and mortality. In this review we are focusing on the challenges in research layout and evaluation, which makes these studies significant to investigate the various reasons of injuries.

The injury is less clearly defined for milder injuries; however, the Injury, also known as physical trauma, which is damage to the body caused by an external force. Most of the injuries leads to loss of lives especially in most of the cases of motor-vehicle accidents. Hospitalization for a person injured due to some accident depends upon the requirements for admission in the hospital and admission standards used in 1970s, which might not sufficient for extra consciousness. The introduction of computerized tomography has modified the admission practices in some hospitals. The person suffered with head trauma are neurologically normal and undergo CT scans for more clear observation. If the emergency department visits are used as a measure of accidental injuries, then the definition of injury becomes entangled with availability of care and factors that influence care-seeking behavior, including personality, pain tolerance, and anxiety.

Visits of uninjured patients to the emergency department after a car crash is also a common practice to reassure his health status because of the advice of an insurance agent or attorney, however, most of the people believe that a gunshot wound or a burn are considered as injuries. Still, it is unclear that the deaths due to poisoning should be classified as injury deaths (Gulaidand Sattin, 1988). This demarcation, which is used in the ICD-9 manual (NCHS, 1991), sometimes draws a fine line; if a child dies from eating foxglove, this is coded as an injury death, but if a child dies from eating botulinum toxin, this is coded as an infectious disease death. Classifying iatrogenic complications as injuries, as is done by the ICD-9, may also not be ideal for some purposes.

If a heavy smoker undergoes angiography in preparation for coronary bypass surgery and dies from a reaction to contrast media, the death will be classified as an injury. In one study of risk factors for death due to injury in infants, the researchers chose to exclude iatrogenic deaths, which they felt would not share the same risk factors as deaths that are not caused by complications of medical care (Wintemute *et al.*,

1988). The injuries may be classified in several ways. Each scheme of classification has its own strengths and weaknesses and the profusion of schemes can lead to confusion and make it difficult to compare findings between different studies. The most accepted classification of injuries is as follow:

1. Anatomical: Spinal and head injury
2. Pathological: Fractures, laceration
3. Etiological: Iron poisoning, gunshots, snakes and other animal bites
4. Intention based: Intentional or unintentional, assault-related, due to medical treatments.
5. Severity: Fatal or nonfatal, severity or trauma score of injury.
6. Event/Accidents: Plane crash, car crash etc.
7. Location: Working place, home, school.
8. Activities: Sports and other physical activities

The ICD-9 manual and MEDLINE use the word "accident" for unintentional injuries. Most injury epidemiologists and public health leaders prefer to avoid this word, because they feel it implies that injuries are due to chance and cannot be prevented (Waller, 1987).The International Classification of Diseases (WHO, 2022), a new category was added to the list which states that "Injury undetermined whether accidentally or purposely inflicted". Some diseases, such as breast cancer or leukemia, almost always result in either a medical encounter and/or death, so complete case ascertainment is a realistic goal. But many injuries do not result in a visit to a health care provider; it is not rare for patients with lacerations or even some kinds of fractures to fail to seek care.

Non-Infectious Disease:

According to the data from WHO non-communicable diseases (NCDs) kill 41 million people per year, which is equivalent to 71% of all deaths globally which includes cardiovascular diseases, cancers, respiratory diseases and diabetes ((WHO, 2022). Non-communicable diseases (NCDs) are also known as chronic diseases, as they exist for a long duration sometimes lifetime and are the result of a combination of behavioral, environmental, physiological and genetic factors. Among all heart attacks, strokes, cancers, chronic obstructive pulmonary disease and asthma and diabetes are the most common (WHO, 2022). The epidemiology of non-infectious diseases is important for case and cohort studies, statistical analysis and significance of data for the public health assessments.

Natural Disasters:

The science of natural hazards and disaster explain the spatial-temporal pattern, its process, mechanism, emergency response and risk mitigation, which require an interdisciplinary and multidisciplinary approach. NSFC (Natural Science Finance of China) and CAS (Chinese Academy of Sciences) together are involved in research and systematic analysis of natural hazards and disasters. The natural hazards and disaster management works on process, mechanism, dynamics, risk assessment and management, monitoring, forecast and early warnings, mitigation, emergency treatments and rescues, and post-disaster remediation and reconstruction.

According to the data of United Nations the losses annually caused by disasters such as earthquakes, floods, droughts, and tornadoes reported are 250 to 300 billion USD in 2015. World Bank reports revealed that the natural hazards accounted for an annual loss of up to 520 billion USD in 2016 globally, which is 60% greater than the losses reported before (The World Bank, 2016).

With the advancement and implementation of modern technologies, there is notable improvement in the disaster risk assessment, forecast, monitoring and early warning, disaster risk governance and mitigation. The study on natural hazards and disasters is the need of the hour to ensure safeguard to our life and economy.

The factors which significantly affect the disasters are climate change, geodynamics, meteorological and underlying surface conditions. Various other fields of study are also correlated with to the study of natural hazards such as geology, seismology, hydrology, meteorology, and some other basic sciences.

The mechanisms of hazards can better understand through various theories and models which have been developed to describe these mechanisms, including ElNiño-Southern Oscillation (ENSO), hydrological confluence, and geological formation (Chen *et al.*, 2013 a, b; Cui *et al.*, 2018; Yang *et al.*, 2021). Various physical models have been developed and proposed in last few years to describe an individual hazard (Ouyang *et al.*, 2015, 2019; Hoffman *et al.*, 2018). Multiple phases and multiple physical fields are adopted to analyze the dynamic processes of disasters using numerous numerical models (Fan *et al.*, 2020; Xu *et al.*, 2020; An *et al.*, 2021), and probability analyses (Sun *et al.*, 2021), which is further supported by advanced computational accuracy and efficiency, especially for climate and weather dynamics (Bauer *et al.*, 2015).

Most of the researches on disaster risk assessment are based on earthquakes, floods and typhoons (Vousdoukas *et al.*, 2018). Forecasting and early warnings of natural disasters require accurate data and information. So far, there are many technological advancements for earthquake prediction and early warning, monitoring and prediction of tropical cyclone (Yamaguchi *et al.*, 2020), and extreme climate and weather warning system (Schiermeier, 2018).

In recent years, remarkable improvement and achievements have been made in disaster management, prevention and mitigation resulting into a significant reduction in the risk and loss associated with the natural hazards and disasters. Progress has been made in constructing and designing the prevention systems for landslides and other geological disasters (Tang *et al.*, 2019). Also, some eco-friendly mitigation technologies are introduced for the mitigation (Palmer *et al.*, 2015). Various new structures, materials, and methods have also been adopted beside the disaster prevention and control (Wei *et al.*, 2020; Xue *et al.*, 2021).

Terrorism:

In last few decades there is a remarkable increase in terrorist activities globally. Hundreds of thousands of peoples have lost their lives and many injured due to the terrorism activities. Most of the terrorist activities involve bomb explosions resulting in the mass casualties which is also affected by the non-coordination between available medical systems and actual demands of medical resources (Stein and Hirshberg, 2003). It is need of the hour to improve and update protocols for evacuation, triage and hospital preparedness (Shapira and Shemer, 2002; Michaelson and Hyams, 2003). As the mass casualties are becoming a frequent event worldwide, there is an urgent need to upgrade and maintain the emergency care services and trauma centers in order to cope with any disaster due to terrorist activities (Shapira and Shemer, 2002; Michaelson and Hyams, 2003).

Exposure assessment is vital in all the environmental-epidemiologic studies. An extensive variety of exposure-assessment techniques and strategies are to be developed for environmental-epidemiologic research. Institutions and research centers are stepped forward to obtain the exposure assessment for personal and biological monitoring and biomarking. Oblique measures such as micro-environmental monitoring, diaries, and mathematical modeling are also in use for exposure evaluation in environmental epidemiology.

Infectious diseases are caused by tiny organisms - such as bacteria, viruses, fungi or parasites who live in or on our bodies. These microorganisms may be harmful or beneficial. But under certain environmental conditions they cause various mild to severe diseases. Infectious diseases can be passed from one person to

another and can also be transmitted by insects, animals and human to human. Mild infections can be treated by rest and using home remedies, while some other are life-threatening infections and require hospitalization.

Injury epidemiology has made great progress in the recent years, adopting increasingly sophisticated research methods of epidemiology. However, challenges also exist for epidemiologists to improve the public health practices in this field. Efforts to improve existing data sources have to be made which can be supported by keeping record of death certificates and hospital discharge registries. More population-based data on injury registries may help in providing information on prevention programs devised by state and local health departments.

The epidemiology of non-infectious diseases is important for case and cohort studies, statistical analysis and significance of data for the public health assessments. The discipline of disaster risk should focus on disaster risk reduction and minimum losses.

Disaster prevention, mitigation, and capabilities to relief the affected peoples should be improved with the help of advance methods of assessment, monitoring and mitigation. In light of human earth's integration and harmony, the researches on disaster assessment and management have been shifted from a semi-quantitative approach of statistical analysis to a quantitative approach. As the terrorism is an important global issue and mass casualties are becoming more worldwide, it is the need of the hour to improve and maintain the emergency care services and trauma centers to cope with all types of disasters and terrorist activities.

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