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Biostatistical methodologies in epidemiology: Importance, distinction and computation of relative risk and attributable risk

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Abstract
Biological and health-related fields including pharmacy, epidemiology and medicine, make use of biostatistics, a statistical tool.

The study of disease transmission, risk factors and the effectiveness of health promotion and disease prevention programs is known as epidemiology, a branch of public health. In epidemiology, metrics such as attributable risk, odds ratio and relative risk are used to assess associations. When studying the link between an exposure and an outcome, epidemiologists rely on two key metrics: relative risk and attributable risk. Attributable risk determines the level of danger connected with a specific exposure, whereas relative risk estimates the probability of illness development in an exposed group compared to an unexposed group. When dealing with numerical issues related to relative risk calculations in epidemiology, it is helpful to compare the risks between groups and see how much the result could be reduced by removing the exposure. Ultimately, epidemiology is essential for public health and evidence-based medicine because it helps to determine potential dangers, monitor the development of diseases, and create efficient countermeasures. The present article talks about biostatistics, epidemiology, relative risk and attributable risk, further numerical problems clarify the calculations and applications.

Keywords: Biostatistics, epidemiology, relative risk, attributable risk, calculation of relative risk and attributable risk, applications of relative risk and attributable risk

Introduction

Biostatistics: The use of statistical methods in biological and health-related areas, such as medicine, epidemiology, and pharmacy, is called biostatistics. In clinical trials, drug research, and healthcare settings, it is necessary to plan studies, analyse data, and figure out what the results mean.

Biostatistics' significance in pharmaceutical research

The following are some of the reasons why biostatistics is so important in the field of clinical and pharmaceutical research:

a. Designing clinical trials, which involves ensuring that studies are adequately powered and regulated.
b. The process of determining if a treatment is more effective than a placebo is referred to as drug efficacy analysis.
c. The monitoring of drug safety through the examination of adverse event reports is referred to as pharmacovigilance.
d. Personalised medicine refers to the practice of employing statistical models to forecast the manner in which individual patients will react to particular therapies.

Applications in pharmacy

a. Drug discovery: Assessing potential drugs by analysing high-throughput screening data.

b. Clinical Trials: Estimating sample sizes, assessing the results of therapy, and evaluating the safety and effectiveness of novel medications.

c. Epidemiology: Examining the prevalence and contributing factors of health-related conditions or incidents in communities. Researchers and medical professionals can make data-driven decisions with the support of biostatistics, which guarantees the validity and reliability of conclusions derived from pharmaceutical research [1, 2, 3, 4, 5, 6, 7, 8].

Epidemiology: The study of the distribution, patterns, and determinants of health-related events in communities is the primary emphasis of the field of epidemiology, which is a subfield of public health. The understanding of the factors that lead to diseases, the determination of the elements that put people at risk, and the evaluation of actions to control or prevent health problems are all significantly aided by it. In the fields of pharmaceutical research and public health, epidemiology is an indispensable source of information for ensuring the safety and efficacy of drugs, preventing diseases, and promoting health.

Basic concepts in epidemiology

1. Epidemiological metrics

Table 1

Epidemiological Measures	1	Incidence	The number of new cases of a disease in a population during a specific time frame. It assists in the evaluation of the illness's likelihood of occurrence.
		Example	Diabetes prevalence in a community measured over a five-year period.
	2	Prevalence	The total number of instances of a disease that are currently being reported at a specific moment in time or during a period of time.
		Example	At a particular point in time, the overall prevalence of hypertension in a population.
	3	Mortality Rate	The quantity of fatalities in a population during a given time frame.
	4	Morbidity Rate	The frequency of diseases or health conditions that are prevalent in a population.

2. Methods used in epidemiological research

Descriptive Studies: The goal of these research is to describe how illnesses or other health issues are distributed within a community. Typical kinds include of:

Table 2

	Cross-sectional studies	Case series
Types	Number of people who have a disease at a certain point in time.	Describe the features that are shared by a group of patients who are suffering from a specific ailment.

Analytical studies: These studies look at how exposures and results are related. Some common styles are:

Table 3

Designs	How to perform
Cohort Studies	Observe a group of people over a period of time to determine how the development of disease is affected by various exposures affecting the group. "Prospective" refers to beginning with the present and moving forward, whereas "retrospective" refers to looking back at data that has already been collected.
Case-Control Studies	Comparing people who have a condition (cases) against people who do not have the disease (controls) is a method for determining risk factors.
Randomized Controlled Trials (RCTs)	In order to ascertain the impact of an intervention (e.g., a substance or treatment), participants are randomly assigned to either an experimental group or a control group.

3. Epidemiological causality

Epidemiologists determine if there is a causal relationship between an exposure (like smoking) and an outcome (like lung cancer). Important considerations when determining causality include:

Table 4

Factors	Indication
Strength of Association	Strong correlations have a higher probability of being causative.
Consistency	Repeated findings of the correlation in many contexts and people.
Temporality	The exposure has to happen before the result.
Biological Plausibility	It must be a biologically logical association.
Dose-Response Relationship	Generally speaking, higher exposure should translate into higher risk.

4. Bias and confounding

Bias: systematic mistakes in data gathering or study design that skew results.

Table 5

Types of bias	Purpose
Selection Bias	In situations where the participants do not accurately represent the population.
Information Bias	There were mistakes made when measuring the exposure or the outcome.

Confounding: The result of an exposure is mixed with the effect of something else. For instance, if smoking is not taken into account in a study about drinking booze and heart disease, it could throw off the results.

Assessment of association in epidemiology

Table 6

Types of measure	Purpose/Indication
Relative Risk (RR)	The ratio of the likelihood of an event occurring in the group that was exposed to it to the probability that it occurred in the group that was not exposed to it. Cohort studies frequently make use of this method.
Odds Ratio (OR)	The ratio of the odds of an event in the exposed group to the odds in the unexposed group. Often used in case-control studies.
Attributable Risk (AR)	The difference in risk between the exposed and unexposed groups, indicating how much of the disease can be attributed to the exposure.

5. Epidemiological transition

The epidemiological transition refers to the shift in disease patterns as societies develop. In low-income countries, infectious diseases tend to be more common, while in higher-income countries, chronic non-communicable diseases (e.g., heart disease, cancer) become more prevalent as a result of aging populations and lifestyle changes.

6. Outbreak investigation

Epidemiologists investigate disease outbreaks by identifying the cause, source, and mode of transmission. Key steps include:

Table 7

Steps	Purpose
Step 1	Establishing the existence of an outbreak (e.g., rise in cases above normal levels).
Step 2	Defining cases and identifying cases through data collection.
Step 3	Describing the outbreak by time, place, and person (e.g., creating epidemic curves).
Step 4	Identifying risk factors or possible sources of infection.
Step 5	Implementing control measures to stop further spread.

7. Surveillance in epidemiology

Table 8

Types of surveillance	Function
Active Surveillance	Involves actively seeking out cases (e.g., by contacting healthcare providers)
Passive Surveillance	Relies on healthcare providers reporting cases to health authorities (e.g., notifiable diseases)
Syndromic Surveillance	Monitors disease indicators, such as hospital admissions, for early detection of potential outbreaks

Applications of epidemiology in pharmacy and healthcare

Drug safety and pharmacovigilance: Monitoring the safety of drugs post-approval by analyzing adverse drug reactions (ADRs) and conducting pharmacoepidemiological studies.

Vaccination programs: Evaluating the effectiveness of vaccination campaigns and monitoring the incidence of vaccine-preventable diseases.

Chronic disease management: Investigating risk factors for chronic diseases like diabetes, cardiovascular diseases, and cancer, and developing strategies for prevention and management.

Health policy and planning: Informing health policies by understanding the distribution and determinants of diseases, and evaluating interventions at the population level.

Infectious disease control: Studying the transmission dynamics of infectious diseases, designing interventions like quarantine measures or vaccination campaigns, and assessing their effectiveness.

Key epidemiological tools and concepts

Epidemic curves: Graphs showing the number of new cases of a disease over time, useful for understanding the dynamics of outbreaks.

Reproductive number: The average number of secondary infections produced by one infected individual in a fully susceptible population. It helps to estimate the potential for an outbreak to spread.

Screening: The process of identifying unrecognized disease in apparently healthy individuals, often used in cancer prevention programs (e.g., mammograms for breast cancer). Epidemiology provides the backbone for evidence-based medicine and public health, helping to identify risk factors, track disease progression, and design effective interventions to protect public health [9, 10, 11, 12, 13, 14, 15, 16].

Relative risk and attributable risk

The relative risk and the attributable risk are two essential measurements that are used in epidemiology to examine the relationship between an exposure (for example, smoking) and an outcome (for example, lung cancer). These metrics assist quantify the strength of the association between exposure and disease.

1. Relative Risk (RR)

Relative risk quantifies the likelihood of disease development (or another outcome) in an exposed group relative to an unexposed group.

$$\text{Relative Risk (RR)} = \frac{\text{Risk in Exposed Group}}{\text{Risk in Unexposed Group}}$$

Risk in exposed group: The likelihood of disease development in individuals exposed to a specific factor.

Risk in unexposed group: The likelihood of contracting the disease among individuals who have not been exposed to it.

Table 9: Interpretation

R value	Indication
RR = 1	There is no correlation between the exposure and the outcome.
RR > 1	Through a positive relationship, exposure is linked to an increased likelihood of developing a disease.
RR < 1	A lower risk of disease is connected with exposure, which is referred to as the protective effect.

Example

If 20% of smokers get lung cancer and only 5% of people who don't smoke get lung cancer:

$$RR = \frac{0.20}{0.05} = 4$$

Accordingly, smokers are four times more likely than non-smokers to acquire lung cancer.

2. Attributable Risk (AR)

The difference in disease rates between the exposed and unexposed groups is known as attributable risk. It measures the degree of risk associated with a certain exposure.

$$\text{Attributable Risk (AR)} = \text{Risk in Exposed Group} - \text{Risk in Unexposed Group}$$

Interpretation

It indicates the proportion of the disease that can be "attributed" to the exposure or that could be avoided if the exposure were stopped.

Example

Using the previously mentioned example:

$$AR = 0.20 - 0.05 = 0.15$$

This indicates that smoking is responsible for 15% of lung cancer cases in smokers.

Key differences

a. To determine the strength of the link, relative risk compares the risk between groups (exposed vs. unexposed).
b. Attributable risk provides a sense of the true risk difference, indicating the extent to which the outcome could be minimized by eliminating the exposure [9, 12, 18].

Numerical problems for calculation of relative risk in epidemiology

The following numerical problems pertain to two groups: one subjected to a specific factor and the other not subjected.

Question 1: Smoking and lung cancer

A study was undertaken to examine the correlation between smoking and lung cancer. The information is as follows:

Category	Developed lung cancer	Did not develop lung cancer	Total
Smokers	80	320	400
Non-smokers	20	480	500

Determine the relative risk (RR) of lung cancer incidence in smokers versus non-smokers.

Table 10: Solution

S.No.	Risk	Formula	Calculation	Result
1	Risk in Smokers	Number of smokers who developed lung cancer ÷ Total number of smokers	80/400	0.20
2	Risk in Non-Smokers	Number of non-smokers who developed lung cancer ÷ Total number of non-smokers	20/500	0.04
3	Relative Risk (RR)	Risk in Smokers ÷ Risk in Non-Smokers	0.20/0.04	5

Conclusion
Lung cancer is five times more likely to strike smokers than non-smokers, according to the relative risk of 5.

Question 2: Alcohol consumption and heart disease

A cohort study looks at the relationship between heart disease incidence and alcohol use. The information is displayed below:

Category	Developed Heart Disease	Did Not Develop Heart Disease	Total
Alcohol Drinkers	30	970	1000
Non-Drinkers	40	960	1000

Determine the relative risk (RR) of developing cardiac disease in individuals who consume alcohol in comparison to those who do not.

Table 11: Solution

S.No.	Risk	Formula	Calculation	Result
1	Risk in Alcohol Drinkers	Number of alcohol drinkers who developed heart disease ÷ Total number of alcohol drinkers	30/1000	0.03
2	Risk in Non-Drinkers	Number of non-drinkers who developed heart disease ÷ Total number of non-drinkers	40/1000	0.04
3	Relative Risk (RR)	Risk in Alcohol Drinkers ÷ Risk in Non-Drinkers	0.03/0.04	0.75

Conclusion
The relative risk is 0.75, indicating that alcohol drinkers have a 75% reduced risk of acquiring heart disease than non-drinkers. This may indicate a protective impact of alcohol use, although more research is needed to prove this.

Question 3: Physical activity and diabetes
A study investigates the link between physical exercise and the risk of getting type II diabetes. The data is provided below.

Table 12

Category	Developed Diabetes	Did Not Develop Diabetes	Total
Active Individuals	10	490	500
Inactive Individuals	30	470	500

Determine the relative risk (RR) of diabetes onset in inactive individuals in comparison to active individuals.

Table 13: Solution

S.No.	Risk	Formula	Calculation	Result
1	Risk in Active Individuals	Number of active individuals who developed diabetes ÷ Total number of active individuals	10/500	0.02
2	Risk in Inactive Individuals	Number of inactive individuals who developed diabetes ÷ Total number of inactive individuals	30/500	0.06
3	Relative Risk (RR)	Risk in Inactive Individuals ÷ Risk in Active Individuals	0.06/0.02	3

Conclusion
Type 2 diabetes is three times more likely to strike inactive people than active people, according to the relative risk of 3.

Numerical problems for calculation of attributable risk in epidemiology
In the following numerical questions, a comparison of disease risk between those that have been exposed and those that have not been exposed is made.

Question 1: Smoking and lung cancer
A research project is being conducted to evaluate the connection between smoking and lung cancer. This is what the data look like:

Table 14

Category	Developed Lung Cancer	Did Not Develop Lung Cancer	Total
Smokers	150	850	1000
Non-Smokers	50	950	1000

Determine the smoking-related attributable risk (AR) for lung cancer.

Table 15: Solution

S.No.	Risk	Formula	Calculation	Result
1	Risk in Smokers	Number of smokers who developed lung cancer ÷ Total number of smokers	150/1000	0.15
2	Risk in Non-Smokers	Number of non-smokers who developed lung cancer ÷ Total number of non-smokers	50/1000	0.05
3	Attributable Risk (AR)	Risk in Smokers - Risk in Non-Smokers	0.15 - 0.05	0.10

Conclusion
The risk that can be attributed to smoking is 0.10, which indicates that smoking is responsible for 10% of all cases of lung cancer that occur in smokers.

Question 2: High blood pressure and heart disease
A study investigates the correlation between hypertension and cardiovascular disease. The data are as follows:

Table 16

Category	Developed Heart Disease	Did Not Develop Heart Disease	Total
Hypertensive	60	940	1000
Non-Hypertensive	20	980	1000

Find the attributable risk (AR) of heart disease that is caused by high blood pressure.

Table 17: Solution

S.No.	Risk	Formula	Calculation	Result
1	Risk in Hypertensive Group	Number of hypertensive individuals who developed heart disease ÷ Total number of hypertensive individuals	60/1000	0.06
2	Risk in Non-Hypertensive Group	Number of non-hypertensive individuals who developed heart disease ÷ Total number of non-hypertensive individuals	20/1000	0.02
3	Attributable Risk (AR)	Risk in Hypertensive Group - Risk in Non-Hypertensive Group	0.06 - 0.02	0.04

Conclusion
Among hypertensive individuals, the attributable risk is 0.04, which indicates that high blood pressure is responsible for 4% of the cases of heart disease that occur in these individuals.

Question 3: Obesity and diabetes
The following statistics are presented from cohort research that investigates the connection between being overweight and the onset of type 2 diabetes:

Table 18

Category	Developed Diabetes	Did Not Develop Diabetes	Total
Obese	120	1800	2000
Non-obese	50	1950	2000

Determine the attributable risk (AR) of diabetes associated with obesity.

Table 19: Solution

S.No.	Risk	Formula	Calculation	Result
1	Risk in Obese Individuals	Number of obese individuals who developed diabetes ÷ Total number of obese individuals	200/2000	0.10
2	Risk in Non-Obese Individuals	Number of non-obese individuals who developed diabetes ÷ Total number of non-obese individuals	50/2000	0.025
3	Attributable Risk (AR)	Risk in Obese Individuals - Risk in Non-Obese Individuals	0.10 - 0.025	0.075

Conclusion
The attributable risk is 0.075, therefore obesity causes 7.5% of diabetes in obese people.

Question 4: Alcohol consumption and liver disease
An investigation into the connection between drinking alcohol and living with liver disease is being carried out. This is what the data look like:

Table 20

Category	Developed Liver Disease	Did Not Develop Liver Disease	Total
Heavy Drinkers	120	880	1000
Non-Drinkers	30	970	1000

Find the attributable risk (AR) of getting liver disease from drinking a lot.

Table 21: Solution

S.No.	Risk	Formula	Calculation	Result
1	Risk in Heavy Drinkers	Number of heavy drinkers who developed liver disease ÷ Total number of heavy drinkers	120/1000	0.12
2	Risk in Non-Drinkers	Number of non-drinkers who developed liver disease ÷ Total number of non-drinkers	30/1000	0.03
3	Attributable Risk (AR)	Risk in Heavy Drinkers - Risk in Non-Drinkers	0.12 - 0.03	0.09

Conclusion
The associated risk is 0.09, which means that heavy drinking is responsible for 9% of liver disease cases in those people [9, 12, 17].

Conclusion/Outcomes
Biostatistics is an essential tool for many disciplines, such as public health, epidemiology, and pharmaceutical research, since it sheds light on the prevalence, trends, and causes of health-related occurrences in populations. By solving mathematical difficulties, epidemiologists were able to determine the risks that might be directly linked to certain behaviours. This article shed light on the possible dangers of lifestyle activities like alcohol and exercise on one's health. To completely comprehend these correlations and how they may affect health outcomes, additional research is required.

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