# **Lecture 2: Epidemiologic Measures Part II**

# **Learning Objectives**

By the end of this session, participants should be able to:

1. Recognise different measures of effect (ratios and differences) and understand their value in epidemiology and public health.

# **1. Measures of exposure effect**

One aim of epidemiologic research is to investigate the association between exposure to a hypothesized **risk factor** (e.g. smoking) and the occurrence of disease. This aim involves a comparison of the incidence (or prevalence) of disease in a group of persons exposed to the hypothesized risk factor against the incidence (or prevalence) in a group of persons not exposed. We can compare these two incidence (or prevalence) figures as a **ratio** to get the relative measure of effect for the exposure on disease. Alternatively, we can measure the **difference** of the two incidence (or prevalence) figures to get the absolute measure of impact of the exposure on disease.

## **1.1. Relative measures of exposure effect**

These measures estimate the magnitude of an association between exposure and disease and indicate how much more likely the exposed group is to develop the disease than the unexposed group.

Different types of relative measures can be calculated, which are collectively known as measures of **relative risk**:

## **Example 1: Hypothetical data from a follow-up study of 10,000 individuals observed for a period of 2 years.**

|  |  |  |
| --- | --- | --- |
|  | Exposed | Unexposed |
| Number initially at risk | 2,000 | 8,000 |
| Deaths during time period | 15 | 30 |
| Person-years at risk | 3,985 | 15,970 |

The relative risk is used as a measure of aetiological strength. A value of 1.0 indicates that the incidence of disease in the exposed and non-exposed groups are identical and thus that there is no association observed between the exposure and the disease in the data. A value greater than 1.0 indicates a positive association, or an increased risk among those exposed to a factor. Similarly, a relative risk less than 1.0 means that there is an inverse association or a decreased risk among those exposed, i.e. the exposure appears to be protective.

Note that, in the above example, the three measures of effect give similar estimates of relative risk. When what is known as the “rare disease assumption” holds true for a population (<10% incidence of disease) the three measures of effect will yield similar estimates. For more common diseases (>10% incidence), the three ratio measures may differ considerably.

## **1.2 Absolute measures of exposure impact**

Information on the relative risk alone does not provide the full picture of the association between exposure and disease. The table below shows the relative risks (calculated as rate ratios) of diseases A and B among those exposed to a certain risk factor. Although the rate ratio is 2 in both instances, the incidence rate for disease A has increased from 5 to 10 per 100,000 person-years at risk, whereas the incidence rate for disease B has increased from 40 to 80 per 100,000 at risk. Clearly, the absolute impact of the exposure is quite different for these two diseases.

In contrast to the relative risk, the rate difference cannot be generalized to other populations because it depends on the baseline incidence in the non-exposed group, which tends to vary across populations.

| **Measure** | **Disease A** | **Disease B** |
| --- | --- | --- |
| Incidence rate in the exposed group | 10 per 100,000 person-years | 80 per 100,000 person-years |
| Incidence rate in the non-exposed group | 5 per 100,000 person-years | 40 per 100,000 person-years |
| Rate ratio | 2.0 | 2.0 |
| Rate difference | 5 per 100,000 person-years | 40 per 100,000 person-years |

Absolute measures of effect are calculated as follows:

If it is possible to assume that the relationship between the exposure and disease is causal, then these absolute measures of impact can be re-interpreted as another measure, the **attributable risk[[1]](#footnote-1)**. The attributable risk is especially useful in evaluating the impact of eliminating a risk factor. Its value indicates the number of cases of the disease among the exposed group that could be prevented if the exposure were completely eliminated. In the above example, by eliminating the exposure we can reduce the incidence of Disease A by 5 cases per 100,000 person-years, and we can reduce the incidence of Disease B by 40 cases per 100,000 person-years.

In the above example, the importance of the exposure as a causal factor was given by the rate ratio and was similar for disease A and disease B. However, from a *public health* viewpoint, the exposure is much more important for disease B because by removing the exposure, more cases of disease B than of disease A will be avoided.

It can be helpful to report the attributable risk percent:

For both Disease A and Disease B above, the AR% is 50%. That is, 50% of the disease experienced *in the exposed group* would be removed if these individuals had not been exposed. Note that the AR and AR% figures are valid only once a causal relationship has been established. You will learn how to consider whether an exposure-outcome association is causal later this term.

Finally, the Attributable Risk has a property which is of particular interest for policymakers:

In the above example, we find out that to eliminate 1 case of Disease A we need to prevent exposure from 20,000 people who would have been exposed. To eliminate 1 case of Disease B we need to prevent exposure from 2,500 people who would have been exposed.

Later in the module you will learn about the Population Attributable Fraction (PAF, lecture 9), which also takes into account how common the exposure is in the population. The attributable risk compares those exposed with those not exposed- it is the excess risk of the disease in the exposed group compared to the non-exposed. It quantifies the risk in the exposed group that is attributable to the exposure.

## **1.3 Effect modification (interaction)**

Epidemiologists are often interested in estimating the causal effect of an exposure on an outcome of interest. The relative risk (e.g. prevalence ratio, odds ratio, incidence risk ratio) calculations are preferred for those interested in causation.

As a secondary analysis, epidemiologists can investigate whether the causal effect of the exposure is the same across subgroups. For example, let’s say we know that exposure to Chemical Z increases the risk of lung cancer by 40% (Incidence Risk Ratio 1.40) over 5 years. We might want to know whether that 40% increase in risk applies equally across subgroups (e.g. for men and women, or for smokers and non-smokers).

To investigate this question, we will *stratify* the calculation of the incidence risk ratio: we calculate the RR for the exposure-disease relationship for each subgroup.

|  |  |
| --- | --- |
| Effect of Chemical Z on lung cancer incidence… | Incidence Risk Ratio |
| …among all participants | 1.40 |
|  |  |
| …among men | 1.36 |
| …among women | 1.44 |
|  |  |
| …among smokers | 1.80 |
| …among non-smokers | 1.00 |

As seen above, the stratum-specific effects of Chemical Z on lung cancer are similar by sex (1.36 versus 1.44). However the stratum-specific effects by smoking status are notably different (1.80 versus 1.00). In other words, Chemical Z causes an 80% increase in risk of lung cancer among smokers and does not have an effect among non-smokers.

The situation observed for smoking status is known as *effect modification* or *interaction*. That is, the stratum-specific RRs differ from each other. Upon observing effect modification, epidemiologists will present the overall RR as well as the stratum-specific RR, as both sets of RRs are of policy interest. For example, for a health promotions expert who aims to reduce the incidence of lung cancer, a ban on Chemical Z only makes sense in a place with a high prevalence of smokers.

Assessment of effect modification by stratifying RRs is useful when considering the *inequity* of outcomes. With stratification, one can observe whether the causal effects of an exposure appear to be similar (equitable) across subgroups, or if there is evidence of inequity. For example, an intervention may be especially effective for men or for high-income people. Or it may become evident that an exposure is protective for one subgroup and harmful for another!

There are statistical tests available to test for the presence of effect modification, though these tests have limitations. Rather than solely relying on these tests, an epidemiologist should use their judgment and argue whether the stratum-specific differences in RR are of clinical or policy importance.

# **References**

Webb P and Bain C. *Essential Epidemiology: An introduction for Students and Health Professional*s. Chapter 2 and 5. Second Edition. Cambridge University Press. 2011.

Bailey L, Vardulaki K, Langham J and Chandramohan D, *Introduction to Epidemiology* Chapter 2 and 3*.* Open University Press, 2005 (Understanding Public Health, Series editors: Nick Black and Rosalind Raine).

Hennekens CH & Buring JE, *Epidemiology in Medicine*, Chapters 4 and 12. Little, Brown and Company, 1987.

1. Note that “risk” is used here in a general sense, and that prevalence, rate, and risk differences can all be used to calculate attributable risk. For this reason, it is particularly important to clearly provide the population denominator and time period used when reporting attributable risk. [↑](#footnote-ref-1)