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Understanding Effect Size: Concept and Interpretation

Umar Hussain,[1] Khalid Rehman[2]

1. Saidu College of Dentistry, Saidu Sharif, Swat, Pakistan
2. Khyber Medical University, Peshawar, Pakistan

ABSTRACT

In scientific research writing, it's crucial to be clear and precise. However, sometimes, when we focus too much on whether results are statistically significant, we forget to think about how accurate and relevant they are clinically. While many researchers highlight the importance of p-values, considering other factors like confidence intervals (precision of effect estimate) and effect sizes for a more complete picture should not be underestimated. Effect size, often ignored, shows how big of an impact an intervention has. It is highly recommended to always report three main statistical measures while presenting the results: p-value, confidence interval, and effect size.

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INTRODUCTION

In two papers,[1,2] we explored the concepts and interpretation of P-values and confidence intervals. In this paper, we introduce another crucial concept applicable to all types of research: the concept of effect size.

Consider an example: a pharmaceutical company introduces an iron supplement for anemic women. After providing the supplement for one month, they observe a difference of 0.7 mg/dL in iron levels across various sample sizes (10, 60, and 100). The reported p-values from paired tests are as follows:

Table 01. Relation of sample size and p-value

Sample Size	Mean Difference	p-value
10	0.45	0.2119
60	0.45	0.03593
100	0.45	<0.001

It's noteworthy that by increasing the sample size, the company obtains significant results with the same effect size (mean difference). If the supplement is increasing the hemoglobin level by only 0.45 mg/dL on average, is it clinically significant? Certainly not. Therefore, it is crucial to always report the effect size alongside statistical significance.

Effect size is magnitude or strength of relationships between variables or the size of experimental effects.[3,4] Examples are frequency, mean, correlation co-efficient, mean difference, risk difference, regression coefficient, odds ratio and relative risk etc. (Table 02)

We are explaining some important effect size as below

1. Risk Difference

The risk difference measures the absolute difference in the probability of an event occurring between two groups. Let's say in a clinical trial assessing the efficacy of a new drug for lowering cholesterol levels, researchers compare the incidence of heart attacks between the treatment group (who received drug) and the control group (who did not received the active intervention). If the risk of heart attack in the treatment group is 5% and in the control group is 3%, then the risk difference would be (5% - 3% = 2%). This indicates that the treatment group has a 2% lower absolute risk of experiencing a heart attack compared to the control group.

2. Odds Ratio(OR)

The OR can quantify the strength of association between two qualitative variables, commonly used in case-control, cohort studies or in logistic regression analysis. An OR of 1 indicates no association between the variables. When the OR is less than 1, it suggests a negative association between the variables. Conversely, an OR greater than 1 indicates a positive association between the variables.

Like an investigator want to know the association of smoking with lung cancer and performed a case-control study. They compare the odds of smoking among individuals with lung cancer (cases) to those without lung cancer (controls). If their results shows that OR=4, we can say that individuals with lung cancer are 4 times more in cases than controls. Don't confuse odds with proportion. A proportion represents part of a whole, such as the number of lung cancer patients divided by the total population. On the other hand, odds compare non-events to events, such as the ratio of non-cancer patients to cancer patients.

Correspondence: Dr. Umar Hussain
Saidu College of Dentistry, Saidu Sharif, Swat, Pakistan.
Email: drumarhussain@gmail.com

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Table 02. Definitions and formulae of common effect sizes

Effect Size	Definition	Formula
Frequency	Proportion or percentage of cases falling into a specific category or group within a dataset.	Frequency = $\frac{\text{Number of cases in a category}}{\text{Total number of cases}}$
Mean Difference	Average discrepancy between two groups or conditions in terms of their means.	Mean Difference = Mean_1 - Mean_2
Correlation Coefficient	linear relation between two numerical variables in term of strength and direction	$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2 \sum(Y_i - \bar{Y})^2}}$
Regression Coefficient	Unit variation in the dependent variable with a one-unit change in the independent variable.	Obtained from the formula $Y = a + bX$, where Y is the outocome (dependent) variable, X is the independent (preditore) variable, a is the intercept, and b is the regression coefficient.
Risk Difference	The difference in the likelihood of an event happening between two groups.	Risk Difference = Risk_1 - Risk_2
Odds Ratio	The odds among exposed divide by odds among non-exposed groups. It shows the relationship between two categorical variables in case-control studies or logistic regression analysis.	Odds Ratio = $\frac{a/b}{c/d}$, where *a, b, c,* and *d* are frequebcies representing the four cells in a 2x2 contingency table.
Relative Risk (Risk Ratio)	Risk of an event occurring in exposed group compared to non-eposed in cohort studies or clinical trials.	Relative Risk = $\frac{\text{Risk}_1}{\text{Risk}_2}$

Table 03. Interpretation of RR in various situation

Relative Risk (RR)	Interpretation	Example
RR = 0	No risk in both exposed and non-exposed group	Not applicable.
RR < 1	A decreased likelihood of the outcome occurring in the exposed group compared to the unexposed group.	In a study on the efficacy of a vaccine, if RR = 0.71, it means that vaccinated individuals have a 29% lower risk of contracting the disease compared to unvaccinated individuals.
RR = 1	Similar risk in both exposed and non-exposed group	In a study assessing the relationship between physical activity and heart disease, if RR = 1, it indicates that there is no difference in the risk of heart disease between active and inactive individuals.
RR > 1	Increased risk of the outcome in the exposed group compared to the unexposed group.	In a study examining the association between smoking and lung cancer, if RR = 2.19, shows that smokers have a 119% higher risk for lung cancer than non-smokers.
RR = 1.45	Exposed group have 45% higher risk than unexposed individuals.	In a study investigating the relationship between air pollution exposure and asthma development, if RR = 1.45, it indicates that individuals exposed to high levels of air pollution have a 45% higher risk of developing asthma.

3. Relative Risk (Risk Ratio)

It's the ratio measuring the probability of an event occurring in control compared to cases or experimental group, mostly used in cohort studies or clinical trials. The interpretation of RR is similar to OR. Let consider that in a cohort study examining the risk of developing diabetes among obese individuals compared to non-obese individuals, researchers follow two groups over several years. If the incidence of diabetes among obese individuals is 20% and among non-obese individuals is 10%, then the relative risk would be (20%/10%=2). This indicates that obese individuals have a 2 times higher risk of developing diabetes compared to non-obese individuals.

In various situations, the values of both OR and RR range from below one to above. Below are examples and interpretations of these situations. As a rule of thumb, always subtract the given value of OR or RR from one, then multiply by 100 to interpret. If above one, the interpretation is harmful, and if below one, interpret it as protective. Remember, OR and RR have similar interpretations except for their use. RR is for follow-up studies as it is the ratio of two risks or incidences.

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