SYSTEMATIZATION OF ERRORS IN A SCIENTIFIC STUDY

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Abstract: *In any scientific study, there is a risk of committing various errors at each stage of research. As a result, false outcomes and conclusions can be obtained, leading to an unwanted waste of energy, time, health and financial resources. The objective of the study is to describe the characteristics and risks of committing errors at each of the stages of any research study. This paper highlights the most common types of possible errors in a scientific study in order to protect the scientists and the whole scientific world from false studies and results. The possible errors at each research stage are pointed out, especially those at first stage, since it is the most crucial one. A well-organized study plan avoids the initial errors and contributes substantially to obtaining true results.*

INTRODUCTION

In any scientific study, there is a risk of committing various errors at each stage of research. As a result, false results and conclusions can be obtained leading to an unwanted waste of energy, time, health and financial resources. In order to render the content more clearly, we will systematize the following steps and assess the possible errors at each stage of the study:

1. Initiation and study design;
2. Statistical observation (data collection);
3. Data processing and analysis;
4. Interpretation and presentation of results.(1,2,3,4)

MATERIALS AND METHODS

This study is a review study. A study on specialized literature and material selection was performed based on relevant keywords.

RESULTS AND DISCUSSIONS

Each stage of the study fulfils a specific set of tasks, and if certain tasks have not been carried out to the end, then the study proves to be wrong. The most common errors, according to the stage of their occurrence, are going to be further listed.

Assessment of errors during the stage of study design

One of the most important stages of any study is the design and planning stage, since a fully structured project of a study is based on research quality. Potential errors occurring during the design stage can have a significant negative impact on quality of the overall study, because it affects all the subsequent stages of the study.(5)

Examples of selective errors that can occur during the stage of study design:

1. The purpose of the study and the primary measurements are not well defined, thus being not clear.
2. The description of the studied null hypothesis has not been clearly performed.
3. The assessment of the studied target statistical totality has not been carried out.
4. The selection criteria and homogenization of the sample has not been clearly defined.
5. Both the initial equivalence for reference characteristics and comparability of study groups have not been reported.
6. The equivalence for reference characteristics has been inadequately tested.
7. The number of participants or observations (sample size) has not been reported
8. The inclusion and exclusion criteria of the study have not been predicted.
9. A preliminary estimation of the sample size / effect size (sample size calculation) has not been performed
10. An improper method of randomization.(3,6)

The effects of selection errors can be reduced to minimum in many different ways. For this purpose, during the stage of study design, the researcher undertakes the following steps:

a) To launch pre-specified and explicit studied hypotheses.
b) To make a concise and coherent formulation of both the goal and objectives and primary measurement results within the original protocol of the study.
c) To determine the target population, where the sample is selected from.
d) To calculate the sample size by means of an appropriate method for the study type.
e) To adjust the sample size according to a multiphase design: the principle of key variables, design effect (deff), non-response (min 10%).
f) To ensure the comparability of the homogeneous lots using the same criteria for both groups (matched groups).
g) To develop data collection tools (questionnaires, code sheets etc.) before defining clear hypothesis, goals, objectives, type and study design, which is likely to exacerbate the effects of selection errors.
h) The study type should match the subject, which is being investigated.(1,6)

Types of errors that commonly occur during the stage of data collection

Information or observation errors occur during data collection on exposure to a factor, which leads to a disease or

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regarding its manifestation and thus may result in wrong estimation of their association. Informational systematic errors generally refer to both wrong method of measuring or improper measuring tool.

- Memory systematic error - derives from a difference between the details on exposure to the risk factor provided by both representatives of the study and control groups.
- Systematic investigation error generating data collection errors - errors related to the quality of the interview (based on researcher's knowledge or suspicion regarding the link between the risk factor and disease).
- Systematic error related to the quality of available data.
- Systematic error of omissions: intentional (lie) or unintentional (forgetfulness).

In order to prevent these biases:

- the investigators will be properly chosen and trained,
- a clear framework of observation will be defined,
- a definite technique to protect the quality of information (single, double, triple blind methods) will be used
- the most up-to-date and valid estimation tools (good sensitivity and specificity) will be chosen.(3,4)

Random errors may occur due to a lack of concentration of the person performing the recording, copying or data encoding. Although it commonly occurs, this type of error only slightly affects the accuracy of results.

A better training of staff, who performs the observation, can prevent systematic and random errors, as well as, by applying a rigorous statistical control.

Quantitative control refers to a volume control of data, verifying their completeness. It involves: verifying the receipt of all forms; and completeness of rubricks etc.

Quality control includes checking the qualitative feature of the collected data. It can be arithmetic and logic.(4,5)

Errors in statistical data during the processing and analysis stage

Confounding errors - may be corrected during the analysis stage by using specific statistical tools, which help in identifying factors of confusion. These are factors that can independently influence the risk of a disease, causing changes in results by mixing independent effect on studied exposure. A factor may be considered confounding, when it is associated with both exposure and disease.

An example of association is between coffee consumption and increased risk of myocardial infarction, which occurs due to the combination of smoking and drinking coffee. Smoking also represents a risk factor for myocardial infarction, which is independent of drinking coffee.

Control of confounding factors may be carried out at each stage of design, ongoing and analysis of the study. It is based on understanding the characteristics of confounding factors (restrictions of inclusion criteria of the studied population, summary , stratified randomisation or stratified and multivariate analysis).

However, it should be noted, that a factor can be referred as confounding, only if it differs in distribution between the studied groups; but if the analysis is performed on groups containing subjects with the same level of confusion factors, then the confounding effect may be considered as controlled.

During the data processing stage, errors should be excluded to the maximum, since they could affect the results; particular attention is paid to:

- avoiding modifications of the method of work during the study;
- thorough following-up of the evolution of subjects, taking into account those out of view(subjects that are not present in the study on a planned assessment date and thus generating incomplete data);
- monitoring and verifying computer- transposed data, in order to remove any data collection or mechanical errors.(2,3)

Analysis and revealing of errors at the final stage of scientific study: interpretation and presentation of results

The correct interpretation of the obtained results at the final stage of study depends largely on the accuracy of applied statistical tests.

The investigator will use appropriate statistical significance test, applied during the research and based on the criteria of using parametric vs. nonparametric tests, according to:

- the measurement scale of the included variables (numeric, ordinal, nominal);
- the normal distribution of frequencies (in case of numeric measurement of scales);
- the degree of homogeneity of the comparable groups (in case of numeric measurement of scale);
- the number of comparable groups (1, 2 or more);
- the category of comparable groups (dependent, independent) etc.(7)

In case of improper compliance with the basic principles of using statistical significance tests, it may lead to an incorrect application and misinterpretation of the results. Examples of errors are mentioned within specialized literature:

1) The use of inappropriate statistical tests:
   a) Incompatibility of the statistical test with the scale of variable measurement.
   b) Unpaired tests for paired groups and vice versa.
   c) Avoiding justification of applying parametric vs. non-parametric tests.
2) Type I error inflation:
   a. correction of multiple comparison has not been performed.
   b. inadequate analysis of post-host subgroups.
3) Typical errors via Student's t-test:
   a. The test is used for categorical variables.
   b. Avoiding the justification of test application (normality and uniformity assessment).
   c. Multiple pairwise comparisons of a number of groups larger than 2.
   d. Using unpaired t-test for comparable paired groups and vice versa.
4) Typical chi-square test errors:
   a. Unjustified use of chi-square test for cases typical for parametric tests.
   b. The Yates continuity correction was not used for small numbers.
   c. The application test when the number of elements in a cell is less than 5.
5) No multivariate techniques for adjustments are used, in presence of confounding factors.
6) Misinterpretation of the results include:
   a. "insignificant" interpreted as "no effect" or "no difference".
   b. drawing conclusions that are not supported by the survey data.
   c. sustained meaning without reporting the statistical test results.
7. Insufficient interpretation of the results:
   a. Type II error is not considered when attesting non-significant results;
   b. The problem is not discussed, when performing test of multiple significance;

c. The potential sources of error selection, information and confounding factors are not enough discussed.(3,6)

At the final stage of processing and interpretation of experimental data of a scientific research, it is highly essential to ensure the interpretation of the results, based on well-motivated scores, in order to avoid the subjective character of the results.(5)

CONCLUSIONS

- One of the most important stage of any study is the design and planning stage, due to the potential errors that might occur during the design stage, which can have a tremendous negative impact on the quality of the study, since they affect all the subsequent stages of the investigation.
- A better training of staff who performs the observation, can prevent systematic and random errors, as well as by applying a rigorous statistical control.
- Control of confounding factors can only be performed by understanding their characteristics (restriction criteria for inclusion of the studied population, summary, stratified randomization, stratified and multivariate analysis).
- The correct interpretation of the obtained results at the final stage of study depends largely on the accuracy of applied statistical tests. It is highly essential to ensure the interpretation of the results based on well-motivated scores, in order to avoid the subjective character of the results.

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