

# Chapter-3

## Essential steps in writing research methodology

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### **Abstract**

A well-written methodology is indispensable for a high quality medical or scientific publication. The common difficulty in methodology write-up is keeping it thorough but succinct, whilst including all of the essentials. This article identifies some vital points of writing an effective research paper methodology based on introduction to the sources of scientific knowing, scientific method, and description of important components of methodology & research methods.

In principle, the methodology section in a research publication should be the major part. The methodology or research methods must provide sufficient information for reproducibility of the experiment by any future workers. Methods can include experiment design used for collection of data and can also include historical sampling and/or theoretical details. The methodology section may contain statistical procedures, equations, tables, figures, flow charts and algorithms for knowledge of reader. Statement of any assumptions, description of the scope, limitations, and a brief description of how the results will be organized and presented, will give a professional touch to the methodology.

### **Introduction**

Some of the most important scientific work starts when people notice something unaccustomed, then start questioning why things are happening the way they do and look for answers.

Therefore, every single one of us is a scientist in our own way. Moreover, there are a lot of scientists out there who do not really use all or even parts of the scientific method every time they start a study. Nevertheless, natural science has been characterized by the scientific method since the 17<sup>th</sup> century as the best way to differentiate the truth, lies and delusion.<sup>1</sup>

For the last few centuries' science has been a dominant "way of knowing." Science is based on experimentation and observations of the natural world and scientific knowledge is considered unbiased and verifiable information to solve day-to-day problems and undertake decisions about life. Scientific findings are portrayed clearly so that others can find the results inherently repeatable. Most of the scientific conclusions are based on empirical data.

The scientific method comprises facts, hypotheses, theories and laws to describe the data and observations collected from the natural world.<sup>2,3</sup> Although all above terms are in everyday use and also common in other ways of knowing, their meaning is utterly different in the scientific context. Therefore, immense unintentional and intentional confusion occurs while dealing with scientific and non-scientific ways of knowing.

One of the main goals of science is to discover the nature at work. Although there are alternative methods for knowing the world science only relies on laws of nature, i.e., objective, testable and consistent patterns in nature. Therefore, before starting a study, a scientist describes his/her research methodology. A thorough grasp on methodology not only results in fruitful research findings but also greatly helps in writing the methodology section of the publication emanating from the study.<sup>4</sup>

## **Scientific Method**

All rigorous scientific studies follow the scientific method: a set of practices and principles designed to advance scientific investigation and contribute to scientific knowledge.<sup>3</sup> The scientific method has evolved over the centuries in several ancient civilizations and reached to scientists of today. The

scientific method commonly comprises seven steps, which are used to determine the cause and effect of relationships between natural objects (Figure.1). Although the basic steps remain the same, there are often some variations in the method and disagreement over its use in scientific research and everyday problems.

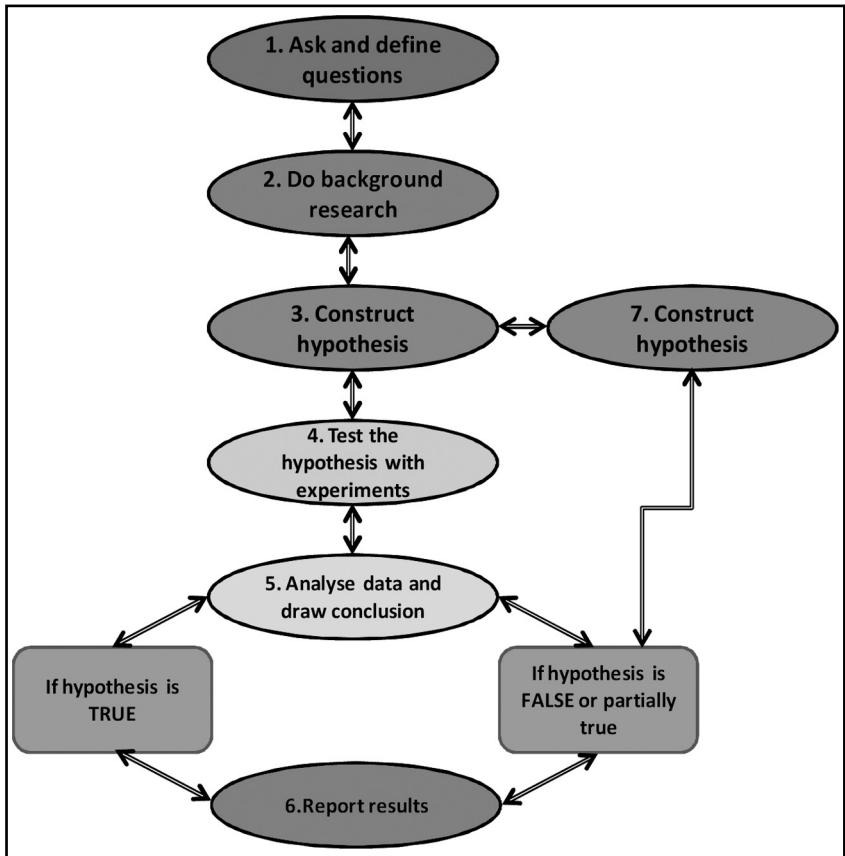


Figure.1: Steps of the scientific method.

### Writing Methodology or Research Methods

Writing the methodology lies at the core of a medical or scientific publication (research proposal, report, article, thesis or presentation in a conference, etc.). Any scientific finding needs to be verifiable by other researchers by replicating the

experiment and guaranteeing the validity. Therefore, describing methodology requires the high level of writing skills and research competence. The best available tools and techniques are needed along with much time and devotion to prepare a good write-up for methodology.<sup>5-9</sup>

The methodology is somewhat different from ‘research methods’. A methodology describes the general philosophical background of selected research methods, including qualitative or quantitative methods used in a research work along with the reasoning for their use. Research methods on the other hand are generalized or standardized and recognized ways of addressing research questions.

The methodology or research methods section should be the major part of a research publication. The section must provide all necessary information for reproducibility of the experiment by any future workers. Methods can include experiment design used for collection of data and can also include historical sampling and/or theoretical details. The methodology section may include statistical procedures, equations, figures, tables, algorithms and flow charts for knowledge of reader. Unless the ‘Guide for Authors’ by a publisher instructs otherwise, present tense should be used in writing methodology.

A well-written methodology provides a great backbone for the entire scientific publication, and allows building extremely strong results and discussion sections.<sup>7</sup> The usual difficulty in methodology write-up is keeping it thorough but succinct, whilst including all of the essentials. Nevertheless, some vital points of an effective research paper methodology can be identified as below:

- i. ***Theoretical, study or sampling population:*** definition of population and the methods of sampling
- ii. ***A general description of subjects/participants:*** who, where, and when the study takes place. Names of localities and participants may be changed to protect privacy if so required, e.g., the study took place on adult female subjects in a suburban area near a large southeastern city.

- iii. **Description of the equipment and the techniques used:** a completely accurate description of the equipment, materials and the techniques used for gathering the data needs to be given. In case of a detailed experiment, a detailed list needs to be added (as a part of methodology or as appendix).
- iv. **Study design and data collection:** attention should be paid to find appropriate information at the very beginning of writing methodology. Identification of all suitable methods for undertaking the task and available reliable sources is necessary. It is also need to describe the research design and to explain how the measurements were made (see Sections 3.1 and 3.2). A concept map outlining the methodology and/or the data collection process is often very helpful to include for the reader.
- v. **Data analysis plan:** it is essential to allude and describe (if needed) appropriate statistical tool(s) used for analysis in such a way that readers will have complete picture of the whole analysis process.
- vi. Statement of any assumptions and description of things or situations that are important about the study.
- vii. Description of the scope and limitations of the methodology
- viii. A brief description of how the results will be organized and presented will give a professional touch to the methodology.

A description of the research (experimental) design procedures and their justification is an integral part of the methodology. Following tasks should always precede a research design:

- \* Selection of a research topic;
- \* A brief description of the research problem including the importance of the proposed study;
- \* Conducting a literature and information review to determine the existing knowledge about the topic; and
- \* Development of objectives stating the purpose of the study, expected results, and potential use of any valuable finding.

Table-I: Components of a research design related to research questions.

Research question	Components of research design
What new information do you need?	Selection of variables
	↕
What approach will you follow to collect this information?	Selection of type of study
	↕
What tools do you need to collect it?	Selection and development of data collection techniques
	↕
Where should you collect it? How many subject do you include in the study and how do you select them?	Sampling
	↕
When and with whom will you collect the data?	Plan for data collection
	↕
What will you do with the collected data?	Plan for data processing and analysis
	↕
Are you likely harming anyone as result of the study?	Ethical considerations
	↕
How can you determine whether your methods for data collection are correct before implementing the study?	Pre-testing the methodology

A good research design always addresses the questions covering the major issues that must be examined/solved.<sup>18</sup> The process of research designing is usually cyclic where completion of each step in the process may entail revisiting the preceding steps. Table-I presents components of a research design related to research questions step-by-step.

Selection of an appropriate type of study is a good start for a medical and biological research. Besides, economic value of a scientific study can be determined with its study design and resulting study type. On the other hand, a type of study can best answer a particular research question when examined with reference to funding and other resources, degree of freedom of researcher(s), availability of research team, prospective applicability of results, scientific significance of the research findings, etc. (Table-II).<sup>10,11</sup>

Table-II: Some examples of problem states, research questions and study types.

<i>Knowledge Status</i>	<i>Type of Research Questions</i>	<i>Type of Study</i>
Little is known about the characteristics or possible causes of the problem.	What is the gravity of the problem? Who are the people affected with the problem? What measures have already been considered by the effected people? What do effected people believe, think or state about the problem, its causes and solution?	Exploratory or descriptive studies: case studies or cross-sectional surveys.
Certain factors suspected to cause the problem.	Is certain factor related or associated with or causing the problem?	Analytical (comparative) studies: cross-sectional, case-control or cohort studies.
Investigating the extent to which a particular established factor causes the problem.	Which factor does cause the problem? Will a change in a particular factor cause a desired change in preventing or reducing the problem? (E.g., smoking vs. pulmonary diseases, safe water vs. intestinal infections).	Cohort, Experimental or quasi-experimental studies.
Using the gathered knowledge about cause(s), assess an intervention for prevention, control or solution of the problem.	How effective is a particular intervention for preventing or controlling the problem? Which one of two or more alternate intervention is more effective? Use of which intervention is cost-effective?	Experimental or quasi-experimental studies.

Broadly speaking two main types of studies can be recognized in biomedical and biological sciences depending on the research strategies, namely, non-intervention studies and intervention studies.<sup>12-15</sup>

Non-intervention studies are simply based on observations and analysis of objects or situations without involving any interventions are known as non-intentional studies and may be further classified as exploratory, descriptive and analytic studies.

**Analytical studies** are considered most important in biomedical and biological research and are undertaken to determine causes or risk factors related to a certain situation, objects, event or problem. There are three commonly used analytical studies in relation to time, namely, cross-sectional, case control and cohort studies (Figure.2):

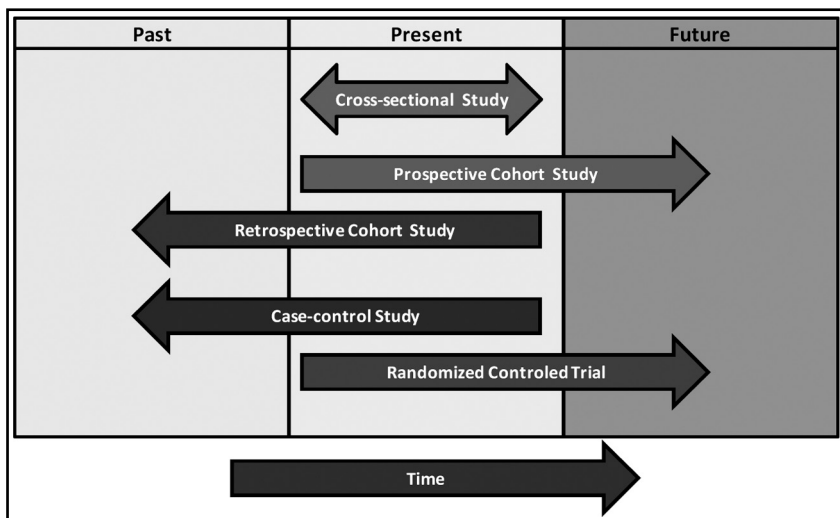


Figure.2: Different study types in relation to time.

Intervention studies involve an intervention (manipulation of objects or situations) and measuring the outcome of the intervention (e.g., physical, chemical, biological or social manipulation/treatment of the objects or situation) and may be designed as experimental and quasi-experimental studies. <sup>9, 12-15</sup>

An experimental study is designed to verify, falsify or validate a hypothesis. In an experimental design interventions/treatments are applied to experimental units, comprising subjects (people, animal) plots of land, test tubes, etc., followed by observations



on the effect of the interventions on the experimental unit. However, experimental units are randomly allocated to at least two groups. The group subjected to an intervention forms an experimental or treated group, while the other group is form the control group.<sup>12-14</sup> Thus an experimental study provides an understanding of cause-and-effect by indicating effect on the outcome of interest when a particular factor (intervention/ treatment) is manipulated.

For determining intended effect of a treatment or intervention on participants, a quasi-experimental study design may be used.<sup>9,15</sup> However, a quasi-experimental study lacks one or more key components of a proper experiment, such as pre-post testing, experimental or control groups, and randomization.

## **Conclusion**

A well-written methodology provides a strong backbone for the entire scientific publication, and allows to build an extremely strong results and discussion sections. Although, some vital points of writing an effective research paper methodology can be identified, all such points cannot be consolidated and applied to all research questions.

Methodology is somewhat different from ‘research methods’. A methodology describes the general philosophical background of selected research methods, including qualitative or quantitative methods used in a research work along with the reasoning for their use. Research methods on the other hand are generalized or standardized and recognized ways of addressing research questions.

The methodology or research methods section should be a major part of a good scientific research publication and must provide sufficient information for reproducibility of the experiment by any future workers. The best available tools and techniques are needed along with much time and devotion to prepare a good write-up for methodology. Methods in medical writing and scientific publications can include experiment

design used for collection of data and can also include historical sampling and/or theoretical details. Moreover, statistical procedures, equations, algorithms, flow charts, figures and tables may be included in the methodology section for knowledge of reader. Statement of any assumptions, description of the scope, limitations, and brief description of how the results may be organized and presented to give a professional touch to the methodology.

## REFERENCES

- 1 Achinstein P. General Introduction to Science Rules: A historical introduction to scientific methods. Johns Hopkins University Press, 2004. pp. 1-5.
- 2 Gauch HG. Scientific method in practice. Cambridge University Press., 2003.
- 3 Gimbel S (edit.) Exploring the scientific method: cases and questions. University of Chicago Press, 2011.
- 4 Kallet RH. How to write the methods section of a research paper. *Respiratory care*. 2004;49(10):1229-32.
- 5 Krishnaswamy KN, Sivakumar AI, Mathirajan M. Management Research Methodology: Integration of Principles, Methods and Techniques. Dorling Kindersley (India), Pvt. Ltd., 2009.
- 6 Kothari CR. Research methodology: methods and techniques. New Age International Publishers, 2013.
- 7 Tayie S. Research methods and writing research proposals. Pathways to Higher Education, 2005.
- 8 Sardanelli F, Di Leo G. Biostatistics for Radiologists planning, performing, and writing a radiologic study. Springer, 2009.
- 9 Ranjan D, Das PN. Biomedical research methodology. Jaypee Brothers Publishers, 2010.
- 10 International Network for Natural Sciences. Types of scientific research. Quality Science Publishing. <http://www.innspub.net/types-of-scientific-research/> (accessed 11 November 2017)
- 11 UNESCO. Definition and description of the various types of scientific research. Research Organization Unit. UNESCO/NS/ROU/14, 1962. <http://unesdoc.unesco.org/images/0015/001542/154284eb.pdf>

- 12 Melnyk BK, Morrison-Beedy D. Intervention Research: designing, conducting, analyzing, and funding. Springer Publishing Company, 2012.
- 13 Martijn PF, Wong KW. An introduction to optimal designs for social and biomedical research. John Wiley and Sons, Ltd., 2009.
- 14 Williams M, Curtis M, Mullane K. Research in the biomedical sciences: transparent and reproducible. Elsevier Science, 2017.
- 15 Thyer BA. Quasi-experimental research designs. Oxford University Press, 2012.

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