How to write a research paper

Dr. K. Satyanarayana

A scientific paper represents the logical culmination of the endeavor of researchers to communicate their findings to their peers. Publications add to the existing knowledge and place new knowledge generated from original research from the informal to the formal domain. While conferences and symposia allow scientists to announce and disseminate new information, the reach of such presentations is limited. For wider dissemination, the new information must appear in the scholarly communication system. Publication in learned journals ensures that the new information serves its intended purpose of reaching peers and readers, who can assess its value and use it. Research papers push and advance the frontiers of science either by triggering further research or by influencing medical practice or public health practice. Traditionally, publication in a learned journal has been considered the most appropriate and acceptable means of informing the peer community of the new information generated. A scientific paper in a scholarly journal adds to credibility of data and authenticity of results reported. Also, journals preserve the new scientific knowledge for posterity and serve as repositories of knowledge.

Publication in a learned journal presupposes writing or recording and disseminating new information in a standard and structured format. A well-written paper reflects clear thinking of the authors. A good paper goes through various pre-publication stages much more rapidly than does a poorly-prepared paper. The referee who is asked to scrutinize the paper for its scientific validity is also likely to do a quick review, if the paper is well-written. A badly written paper, on the other hand, frequently puts the referee off, precluding immediate scrutiny. If the message of the paper is unclear at a glance, the reviewer tends to put off reading it to a later time. If a paper lacks clarity, then even if the research work is of good quality and the findings are important, its key message(s) may be lost in the verbiage. On the other hand, due to its easy comprehensibility, information in a well-prepared paper gets assimilated into the common pool of knowledge quite rapidly. It is also likely to be read by a wider audience and cited more often. In an extreme case, a badly prepared paper with valid results may even get rejected, at least at the stage of first scrutiny. It is not uncommon for an editor to receive back a badly-written paper from the reviewer requesting resubmission by author(s) after the message has been made clear. Referees and journal editors may occasionally help authors rewrite papers, but only when the authors are young or inexperienced, especially those from an institution with limited expertise. The scientific quality of work may not ensure publication of a poorly drafted paper; this is particularly true of papers submitted to international journals with fierce competition for publication. With over 85% rejection rates for papers submitted for publication, badly written papers stand a poor chance.

The quality of a scientific paper often depends on the planning that goes in before the actual paper is written. Several key elements need consideration while preparing the first draft of the paper. Have the data been properly analyzed? Have they been arranged properly in the form of tables? Do the entire data need to be included? What are the key and the supplementary messages? Are these really supported by data? Sometimes, after the data have been tabulated, one realizes that some key links are missing and that it is necessary to repeat some experiments, run more tests or to extract more data from the original data sources or laboratory notebooks. Only when these issues are settled, should the actual writing start.

Writing is frequently a very difficult exercise. It has no set rules. However, writing research papers is easier than non-scientific writing because of its structured format and the availability of a large pool of information and advise not only for new authors but also for experienced ones. Several books are available on various steps for writing a good paper. Edward Huth, who has been an editor of Annals of Internal Medicine has provided some key points that should be kept in mind before starting actual writing. The first and foremost element is to decide on the most crucial message of your paper. Is the key finding of your research important enough for publication in a learned journal? What are the other important points or key message(s) that you are trying to convey? Are they important enough to warrant a research paper or will a simple letter to editor or a short communication suffice? Often, a question which was unanswered when the research work is initiated, may have been answered, either completely or partially, by someone else during one or more years that it took for the work to be completed. In such a case, is there still sufficient new information in your work to merit writing of your paper? If so, what kind of paper would justify communication of this information -- full paper, short paper, case report, etc.

If there is enough justification for writing a paper, the next issue that needs to be ascertained is the 'newness' or 'originality' of the information being reported. Are you the first to report these findings? Or is it the first report from your region or country? A thorough literature search is a must. For most biomedical research papers, a good MEDLARS search is adequate. Though research problems are usually chosen after a thorough literature search, other publications addressing the same or similar questions may have already appeared. Some times, even if a paper has already been published on a topic, you may still be able to publish another one, if the methodology adopted is more sound, the sample size larger, or the study design more robust, rigorous or superior. Also, it is possible that your findings were discovered by chance or as a byproduct of a main study, and hence no literature search was done beforehand. Literature search helps in many ways. It reinforces your confidence that the work being reported is new. It also gives one a comprehensive global picture of the work being done in that area. Many times, a fresh literature search may save one the embarrassment of having the referee point out that similar findings have just been reported and have 'inadvertently' not been included in your paper. One of the major flaws of Indian papers is the absence of thorough grasp of current literature, as reflected by failure to cite recent papers; international journal turn down such papers merely on the grounds that the authors are ill-informed about the area of their own research. Finally, the new paper(s) turns up on literature search may well answer a critical missing link in your hypothesis.

Once the issue of newness or originality is established, further questions arise on the importance of the work being reported. Sometimes, even if referees recommend a paper, the editor may decide to reject it, using what is called the 'so what' principle. When confronted with a surfeit of good papers -- a frequent occurrence with the rejection rate of good journals averaging 65% to 75% -- editors use a simple question to arrive at the decision. What happens if this paper is not published?. Will my journal and readers lose any critical information? You have to therefore demonstrate that there is adequate interest among scientists in the topic on which you are working and that your paper will stimulate further work in the area.

Having established that there is enough new information that warrants publication, the next issue to be resolved by the author(s) relates to the readership to whom the paper is being addressed and the journal to which it is likely to be sent. Is it meant for a small group of superspecialists (say, pediatric gastroenterologists), a larger group of specialists (gastroenterologists or pediatricians) or would it interest all practising physicians? This would decide the journal to

which this paper will be sent. It is important to understand that most international journals do not serve the entire international medical fraternity, but serve their own community i.e. their readership. This issue has been discussed in greater details elsewhere in this book.

Another crucial issue that needs attention relates to authorship. As a general guideline, all those who have contributed to the 'intellectual content' of the paper should be included as authors. In other words, those should be people who have participated significantly in the study, helped in writing parts of the paper, or in revision of intellectual content of the paper. Many journals insist on some form of 'undertaking' on this issue before the paper is considered for publication. Some international journals ask the authors to spell out their relative contribution in the research work being reported. The issue of who qualifies to be an author has been discussed in greater detail elsewhere in this book.

Having sorted out these issues, it is time to begin the long journey of communicating the information generated at the laboratory bench to global scholarly communication system and actually start writing the paper. It is imperative that you collect all the relevant material viz. your scientific data in the form either of tables or of figures/charts, other supportive documents, reprints of crucial papers etc, before you start. Simultaneously, start obtaining permissions relating to material used for research, including any unpublished information used in the manuscript, any research tools used or material obtained from others, etc. It helps to list your salient findings n a logical sequence, usually the order of their importance.

Basically, all scientific papers attempt to report some novel and hitherto unknown information, and present arguments supporting its originality, state how these differ from previous reports indicating the reasons for these differences, and try to convince readers of the credibility of their findings. A scientific paper is thus a structured write-up of a set of ideas, which must be arranged in a logical sequence.

What is a logical sequence? First the research question or hypothesis studied is described in terms of its importance and relevance, indicating the necessity of the present study. Evidence is then presented on the main and subsidiary points based on the data gathered, maintaining the same sequence throughout. The credibility of authors' data gathered through planned experiments, is explained in the light of similar findings reported previously. The implications of their findings are discussed in the light of available knowledge, especially if there is any evidence to the contrary. Arguments are presented defending and justifying the new points made in the paper. And, finally, a verdict is made in terms of conclusions, implications and recommendations, if any, for further work.

The size of the paper is also crucial. It may not be a good idea to put several good ideas in one paper. It may make sense to separate these into two separate papers. Having too many ideas in one paper increases the size of the manuscript and could well dilute the crucial message. The chances of a paper's acceptance are usually inversely proportional to the size, and number of tables and figures it contains. In addition, when a topic with two sets of experiments is appropriately split into two papers, the probability of getting at least one of them accepted in a good journal more than doubles. If there is one issue on which editors agree, it is the size of the article that comes into the editorial office. All editors, as also referees, like short papers.

Until the early part of the 20th century, scientific papers were written mostly in the first person singular form, describing the findings in a loosely structured paper. When there were not many papers to be read, it was easy for scientist-readers to understand any paper as long as it

interested them. When the publication of papers increased substantially during the 1950s and early 1960s, it became difficult for scientists to cope with the literature explosion. Several strategies were tried to bring uniformity and standardization in scientific papers. It was felt that this would save readers' time and help them grasp the papers more quickly and effectively. The most significant and successful attempt was made by Sir Bradford Hill, a British statistician, in 1965. The structure that he proposed for presentation of information in scientific papers, with a clear-cut demarcation between sections, is shown in Table 1.

Table 1: Structure for presentation of information in scientific papers

Question	Contents
Why did you start the work?	A clear statement of problem or hypothesis that the paper addresses, forming the '*Introduction'* section.
What did you do to get the data?	The method by which the hypothesis or research question was tested, forming the '*Material and Methods'* section.
What were the answers obtained?	Salient findings and supporting evidence, forming the *'Results'* section.
What does it mean or what are the implications of your study?	Interpretation and meaning of findings, forming the *'Discussion and conclusion'* section.

To sum up this would form the structure of the scientific paper as we know now, the so called **IMRAD** format: Introduction, **M**aterials & Methods, **R**esults and **D**iscussion. The IMRAD format is now accepted by most international scientific journals, especially the biomedical journals. The International Committee of Medical Journal Editors (ICMJE) also recommends it as the standard format of writing and publishing original research. The concept of 'Structured Abstract' that came into vogue recently has further enhanced comprehension of the contents of scientific papers.

How do you actually start writing a paper? It helps to begin with a rough outline of the paper. From the Tables and figures, sketch briefly a summary of the results that you have obtained. One could then write the Results section, detailing the salient findings. A few possible tentative titles could be thought of. This could be followed by the most difficult part of the paper, the Discussion. Introduction could follow. Material and Methods and References sections are easy to write as information on these is readily available. The abstract could be written at the end after the paper is finalized. Now is the time to finalize the title of the paper as the entire paper is ready. At the first attempt, each section could be briefly described followed by a little elaboration, providing only the essential details. The most important consideration is the format formed just before you start writing the paper; without this rough blueprint, the paper may evolve in a different direction than you had intended. If the structural framework of the paper is not clearly defined, crucial messages may not get sharply focused leading to avoidable delay in publication.

Only a few gifted writers can chisel fine prose at the first go. Most of us need to work like a sculptor, who first makes a rough model and then chisels it down to perfection. Therefore, the key is to start and make a first draft and then improve on it. Writing a paper is like stringing pearls into a necklace. There is an optimum order for the pearls, and it not always necessary that

all the pearls to are used. It is often painful to leave out data but one has to exercise self-discipline; otherwise, the referee or the journal editor will do it for you. This could however mean significant delay in publication.

Sometimes, especially in areas where much data are not available, it helps to when write the first draft of the a paper before you read too much of published literature.

In scientific communication, more than any other means of communication, discussion, debate and criticism add value to writing. For those who are writing a paper for the first time, it is important to understand that writing and rewriting are the only means to improve a paper. There are however some other established methods that are beneficial to both new and experienced authors. Once the first draft is ready, put it aside for a week or two. Re-reading after this period helps one find several errors in text, explanations, missing references etc. Now rewrite the paper to remove these infirmities; this should significantly improve the clarity of your paper. It also helps to eliminate typographical errors and other embarrassing mistakes. A typographical error on the first page of introduction or abstract indicates that the author is careless. Such errors tend to lead referees and editors, rightly or wrongly, to conclude that the paper is bad and should be rejected. They conclude that the author is likely to be sloppy in substance as well. Sometimes they may be right.

After the second draft, you can share the paper with others. There is what is called the 'colleague treatment' and is unique to scholarly writing. It is not possible or easy for an author to see the defects in his or her manuscript. Familiarity of the text dulls the eye and makes it difficult to pick up even the most glaring mistakes. The value of external criticism in improving the quality of presentation cannot be overemphasized. At this point of time, the draft paper should be given to the co-authors, and a dependable colleague. The colleague chosen should be someone who would give honest criticism of the paper. This colleague need not be from the same sub-specialty. Sometimes, a person who does not understand every detail in a paper may be a better judge of whether a paper is comprehensible or not. If the purpose of writing a research paper is to communicate new information to peers, nothing could be more beneficial than a colleague pointing out areas that do not make sense or, at least, complete sense.

Suggested Reading:

- Huth, E.J. How to write and publish papers in medical sciences, 3rd ed, Williams & Wilkins, Baltimore, 1999
- Day, R.A. How to write and publish a scientific paper. Cambridge University Press, 1995.
- Naik, S.R. Editor, Better medical communication, S.R. Naik Publisher, 1988