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A Guide for Writing in the Scientific Forum

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Abstract

Background—When considering the importance of scientific writing in disseminating new discoveries and ideas, it is quite remarkable that few physicians have received any formal instruction in this essential process.

Methods—This paper focuses on the fundamental principles of scientific writing that also include a “style and grace” component.

Results—The art of good scientific writing is to convey scientific materials in a clear and interesting way, while avoiding incomprehensible sentences that only serve to disguise marginal contents within the article.

Conclusions—The goal of this paper is to encourage authors and readers to critically examine the art of scientific writing to overcome the barrier to effective communication.

Keywords

Scientific writing; style; guide

Scientific writing is often considered a “necessary evil” in order to ascend the academic ladder. After all, the phrase “publish or perish” is still commonly used. Academic promotion, improving knowledge of a subject, establishing professional contacts, disseminating knowledge,¹ and obtaining grant funding are a few reasons why physicians choose to publish.

Physicians may feel the pressure to publish, but scientific writing is a learned process and one in which few academic physicians have received any formal instruction.^{2–6} Although scientific writing often has a reputation for being dense or unreadable,^{7–11} we hope to assist physicians to develop a manuscript that is enjoyable to write and read.

Getting Started

We will assume that you have already completed a well-conducted scientific study and are ready to write up your findings for a peer-reviewed scientific journal. If you are new to

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scientific writing, it is helpful to have a mentor, particularly an experienced writer in your field who can guide you. If you are writing about a research project, you should have formed a hypothesis to your research question before analyzing any of the data. You will want to do a thorough literature search of your topic so that you are familiar with all published work. Writing an outline may seem elementary, but it can be an important tool to organize your thoughts.¹² Think about what journals you may want to publish in and follow their publication guidelines as far as word count and paper structure. Choosing your journal early on will help you to write for the readers of a specific journal. You do not want to “write down to” your readers or include details that have been published previously, such as an established surgical technique. You also want to think about the conclusions of your paper before you begin to write—the “so what?” question. Why is this project novel? What makes it different from other published studies on this topic? Why is it clinically relevant? Table 1 gives a list of “dos” and “don’ts” for scientific manuscript writing.

Writing the Abstract

Although the abstract is the first writing component of a scientific manuscript, it should actually be written last. You should check the format of the journal that you are submitting to, but a structured abstract generally has four sections: Background/Purpose, Methods, Results, and Conclusions. After the rest of the paper has been completed, you can select a sentence or two from the appropriate areas (Introduction, Methods, Results, Discussion) to include in the aforementioned abstract sections. However, the abstract is not the introduction and should not be cut and pasted from the introduction. An abstract that is identical to the introduction in any paper or grant will be summarily rejected because of the perceived lack of effort to construct a thoughtful synthesis of the materials in the paper. You should be concise and state the purpose usually in one sentence. The emphasis should be placed on the methods and results, which should each be written in three to four sentences. The conclusion can typically be written in two sentences—the first summarizes your findings and the second makes a conclusion.¹² Only data contained in the paper should be included in the abstract—it should not contain any new data. Care should be taken in writing the abstract. Many physicians will not read past the abstract if it is not well-written. Similarly, many readers only need to scan through an abstract to determine whether a manuscript is pertinent to their topic of interest.

Writing the Introduction

Before any writing begins, it is important to perform a thorough literature search. You should be familiar with all the recent advances in your field of study as well as important historical references. “Incomplete, inaccurate, or outdated review of the literature” is one of the common reasons for manuscript rejection.¹³⁻¹⁵ The Introduction should be written in the present tense.¹⁶ You can begin in the first paragraph by mentioning the most important references and stating the research problem. The second paragraph can elaborate on the magnitude of the problem and unresolved issues. The final paragraph describes the rationale for your study and should end with the purpose: a hypothesis of what you are expecting to find.¹² Examples of elements to include in a well-written manuscript are shown in Table 2. Of course, before you begin writing or even analyzing your data, you should have developed a hypothesis. Your observed results may not match your expected results when you analyze your data, but we will discuss that in the Discussion section.

Writing the Materials and Methods

The traditional sequence of a manuscript is Introduction, Methods, Results, and Discussion, which has been referred to by the acronym IMRAD. Pollock et al. have suggested drafting

the manuscript in the sequence MRDAI.¹⁷ The Methods section should be written in enough detail that another researcher would be able to duplicate your study.¹² In fact, the Methods section is most often responsible for outright rejection of a manuscript¹⁸ because the lack of detail is a common problem.¹⁹ This is the section where you want to state everything you did (controlling for biases, validating research tools) to increase the reliability of your results.

The Methods section should be written in the past tense.¹⁶ To avoid any confusion by the readers, you may want to start by describing the type of study you performed: randomized, prospective, retrospective, case-control, etc. If it is a study involving human subjects, you should state that you obtained Institutional Review Board approval and include the subject inclusion and exclusion criteria. Include how and from where subjects were recruited as well as randomization and blinding procedures. Including patient characteristics such as disease stage or severity and comorbid conditions can help the readers to determine whether the findings of the paper are applicable to their patients of interest.¹⁶ It may be helpful to include a diagram of the number of subjects recruited, how many were excluded, losses to follow-up, or withdrew, and your final sample size. Figure 1 shows an example of a similar diagram from a meta-analysis. Details of the sample are included in the Results, but most journals will require that the previously stated information is included in the Methods. Likewise, preliminary experiments or pilot studies can be included in the Methods section if they helped you to arrive at the methods used in your study.² If equipment was used, the equipment manufacturer, model, and calibration methods should be included. It may also be helpful to include a timeline that shows how and when different aspects of the study protocol took place.¹² The final paragraph of the Methods section should describe the statistical analysis. You may need assistance writing this paragraph from your statistician, if you did not perform the analysis yourself. You should include the tests used, the p-value that determined statistical significance, and whether an a priori power analysis was conducted to decide your necessary sample size. The power and sample size calculation is often a neglected area of scientific presentation and should always be performed prior to conducting a study.

Writing the Results

In writing the Results section, it is important to “only state the facts!” The Results section is not a place to include citations or your interpretation of the data. “Make your point with data, not arguments.”²⁰ The Results section should be written in the past tense.¹² You should begin by describing the study sample demographic data, which can be done in a simple table. The data reported in a table should not be repeated in the text. Furthermore, tables and figures should stand on their own. You should include a title, legend, and labels for the axes. The readers should be able to determine what the table is about by only looking at it and not having to read any text. Any percentages should include raw numbers so that the readers are not misled by a large percentage (such as 25%) that only came from 1/4 subjects.

It should be noted that the word “significance” only be used to describe statistical significance. You should avoid using significant as a synonym for importance. General phrases such as “showed a trend toward” when results are not statistically significant often tend to signal a poor study design and should be avoided.² Also, the word “data” is plural. Thus, it is correct to state, “Our data are...” rather than “Our data is...”

Writing the Discussion

You should begin writing the Discussion by discussing the major findings and relating them to your hypothesis. Did you reject your null hypothesis with your findings or were you unable to reject it? Although being unable to reject your null hypothesis (for example, seeing no significant change between your treatment groups) may seem like a “crash and burn” situation, you can still publish your paper. It has been stated that “Manuscripts describing studies with negative findings are especially tough to get accepted by medical journals, with publication rates generally less than one-third that of manuscripts describing studies with positive findings.”²¹ You should describe whether you conducted an a priori power analysis to determine your necessary sample size in order to avoid a beta error (concluding that there is no difference between treatment groups when there is in fact a difference). Chung et al. found that 82% of negative studies in a major hand surgery journal had inadequate statistical power (probability to detect a true difference, if a difference is present) to support their conclusions.²²

Previous studies have shown that physicians, particularly those with no formal education in epidemiology and biostatistics have a limited ability to interpret study results.²³⁻²⁵ However, more than 58% of medical residents use statistical information in the published literature in forming opinions or when making medical decisions.²⁶ Thus, it is important in the Discussion to spell out the meaning of your statistical findings without appearing condescending to your readers. When describing your study, past tense should be used, but present tense should be used for established knowledge from other investigators.¹⁶

In addition to the meaning of your data, you want to discuss the importance. You should compare and contrast your results to those found in the literature. Care should be taken not to criticize other published work. Similar findings will strengthen your results, but you should still point out how your study differs from previous similar studies. When explaining the study results, it is important to consider all possible explanations rather than just those that fit your preconceived biases. However, you should avoid coming to conclusions that are not supported by your data. Some of the most common criticisms of the Discussion section by editors' and reviewers' involve “coming to erroneous or unsupported conclusions, drawing conclusions disproportionate to the results, uncritically accepting statistical results, and interpreting the findings in a manner not concordant with data reported.”¹⁸ Unless you are absolutely sure that it is true, you should avoid statements such as, “This is the first study to demonstrate...” After all, there are few studies that change the course of scientific progress, but some authors are overly enthusiastic in advertising their study as a seminal contribution.¹⁹ It is also important to discuss the clinical relevance of your findings and how patients or physicians may benefit from them.²⁷

In the Discussion section, it is essential to address the limitations and strengths of your study. We have stated them in this order rather than as strengths and limitations because it is nice to leave the readers on a good note when he/she finishes reading your paper. Thus, acknowledge your study's limitations first. One limitation may include a lack of generalizability, which often happens when trying to obtain a homogeneous sample. You may use your study's limitations to make suggestions for future research. If not, you should still include suggestions for further research, usually in your concluding section. This last paragraph or last few sentences can also be used to propose ideas for changes to medical practice.²⁷

Remembering Style and Grace

Throughout the writing and editing process, it is important to remember the style and grace that is needed in writing any good manuscript. First of all, do not make the readers and

reviewers work unnecessarily! When reading through your paper, try to keep the reviewers in mind. When a question is left unanswered or is not answered until the Discussion, the readers can get frustrated and give up on your paper entirely. Make it easy on them by explaining early on (usually in the Methods) why you did what you did—whether it was by choice or not. On a similar note, consistently use the same word to describe the same thing in order to provide continuity and avoid confusion.²⁸ Of course, it is also helpful to have someone else read your manuscript—a colleague and maybe even a layperson. A different set of eyes and a different perspective can point out areas that need clarity.

A few grammatical considerations will assist your readers. Use transitions for flow. “Transitions let the reader know how each sentence relates to the story and how parts of sentences are related.”²⁸ You should also limit the use of passive language. Although scientists tend to use it because they think that it is objective and do not want to indicate who is conducting a certain action,²⁸ it becomes quite boring to continually read, “The sutures were removed...” and “The data were analyzed...”

Other grammatical points include writing with precision. Instead of saying that you observed a change, say that you measured an increase or a decrease.²⁸ Along this point, you should avoid wordiness and using long or unfamiliar words when a commonly used shorter one will convey the same message.²⁸ Words such as marked, revealed, and demonstrated are overused and have lost their intended meaning.²⁹ Although it is common for writers, especially inexperienced ones, to try to use “flowery” language, it is best to remember that “less is more.” You can delete unnecessary adjectives and adverbs such as fundamentally, very, and great. You should also examine your writing for wordy phrases such as, “It is often the case that...”²⁸ or “In our opinion...” If it is not your opinion, it should have a citation attached to it. The words while and since have primary temporal definitions, but while is often used as a synonym for although or whereas and since is commonly used instead of because.²⁸ Be mindful of these subtleties that can slow down your readers and cause them to misinterpret what you are trying to say.

Well-written paragraphs usually start with making a point in the first sentence and then developing that point throughout the paragraph. Focusing on a single major point in each paragraph allows the readers to follow the author's train of thought.²⁸

Grantsmanship

Although the focus of this paper has been how to write a scientific manuscript, we have decided to include a section on grant writing. After you have successfully written and published a few papers, you may hope to get funding to conduct your own research and compete in a different arena. An in-depth article on grant writing was written by Chung and Shauver,³⁰ but we will touch on the basics. In manuscript writing, you have already conducted the research whereas in grant writing, you have probably conducted preliminary research but want to obtain funding to study questions by expanding on that preliminary research. Of course, style and grace are also important in grant writing. The general formats of manuscripts and grants are similar. In manuscripts you have an Introduction, Methods, Results, and Discussion. Likewise, in a National Institutes of Health (NIH)-formatted grant, you have Specific Aims and Research Strategy (incorporating the Significance, Innovation, Approach, and Preliminary Studies/Progress Report).³¹ The Introduction corresponds to the Specific Aims where the goals and hypotheses are presented. The research question is the most important section of the grant.^{32, 33} The impact (one of the new NIH review criteria) of your proposed research on the research field should be spelled out for the reviewers in the Specific Aims. The Methods section corresponds to the Approach section. New NIH page limitations have reduced the overall size of the grant, encouraging researchers to be less

detail-oriented in describing their methods. The Results section corresponds to the Preliminary Studies/Progress Report. Although a grant does not have a Discussion section per se, your “so what?” question is extremely important to answer the significance of your proposal. The Innovation section should describe whether your proposal introduces novel concepts, approaches, or methodologies. 34

New NIH review criteria consist of an overall impact score that reflects reviewers' “... assessment of the likelihood for the project to exert a sustained, powerful influence on the research field(s) involved...”³⁴ The five core review criteria remain the same as before, but have been prioritized as Significance, Investigators, Innovation, Approach, and Environment.³⁴ Guidelines published by the NIH regarding how to prepare for grant writing are similar to manuscript writing, including finding a mentor, preparing an outline, and soliciting feedback from colleagues.³⁵ As described previously for manuscripts, it is best to make the grant reviewers' lives easy. One way this can be done is by separating each of the review criteria into identifiable sections. You can also get a feel for the questions reviewers might ask, depending on their research interests, by identifying the review committee that your proposal will be directed to and seeing who on that committee will most likely review your proposal. Although you should search the literature to obtain background and see if similar studies have been conducted, you should also search the NIH Research Portfolio Online Reporting Tool (RePORT) to see if similar studies have been funded.³⁶

General Reminders

There are a few other general reminders to keep in mind. Follow the journal guidelines as far as formatting, line numbering, word limits, figures, and citations. This will save you the time and hassle of having the editor send the paper back to you before it can be sent out for review. Aesthetics is another item to keep in mind. Before submitting (especially when submitting online), preview your paper to be sure that you do not have a heading at the end of a page without text underneath it. If you have large blocks of text, it might be a good idea to add one or more subheadings. Make sure that your font is the same throughout and that you have not overused italics. Some reviewers do not like to see italics because the overuse of italics may signal to the reviewers that the authors consider the materials presented to be too complex for the reviewers to understand. Spell out abbreviations the first time you use them but do not try to avoid word count limitations by bombarding the readers with multiple abbreviations. Non-universal abbreviations force the readers to remember their meanings and substitute the full phrase each time they appear.²⁹ An abbreviation should be used often enough in the paper, preferably more than 10 times, so that the readers do not forget the meaning.³⁷

Of course, proofread, proofread, proofread, and use spell check! As previously mentioned, allow someone else to proofread, too. You should also look through your final manuscript and notice your citations. Are you continually citing the same author? If so, this can show bias. Make sure that you are citing a wide range of authors and not reiterating someone else's ideas.

If you have conducted a randomized, controlled clinical trial, you should follow the Consolidated Standards of Reporting Trials (CONSORT) statement.³⁸ The CONSORT statement requires authors of a randomized, controlled clinical trial to fill out a checklist of the key information that should be included.¹⁶ Figure 2 has a general manuscript checklist of items to include.

Although you should be optimistic, you should also remember that there is a chance that your manuscript will be rejected by the journal you initially submit to. The acceptance rate of clinical research-based manuscripts submitted to major biomedical journals is 30-40%.³⁹

The acceptance rates for journals such as New England Journal of Medicine and JAMA is less than 10%.¹⁶ Even if your manuscript is not accepted, the comments by the reviewers will most likely help you to identify your weaknesses and improve your paper. If your manuscript is accepted with revisions (major or minor) then congratulations! However, you may still have plenty of work to do. In revising, draft a response letter with each reviewer's comments typed out and how you have addressed them. Also state where in the paper the revision can be found (i.e. Methods section, paragraph 2, line 2). Remember to be polite; if you are choosing not to make a suggested revision, you should give a reason for doing so. Although it is not necessary to do every suggested edit, your manuscript will not be looked upon kindly if you choose to make a rebuttal for all or the majority of suggestions.

Although scientific writing can be a long and tedious process, your writing ability will continuously improve. Remember that, "Only the researcher who is competent in the art of written communication can play an active and effective role in contributing to science."⁴⁰

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Figure 1.

A study attrition diagram from a meta-analysis showing the number of references retrieved and excluded from review.⁴²

(Adapted from Margaliot Z, Haase SC, Kotsis SV, et al. A meta-analysis of outcomes of external fixation versus plate osteosynthesis for unstable distal radius fractures. *J Hand Surg.* 2005;30A:1185-1201 with permission from Elsevier)

Figure 2. Manuscript checklist.¹⁶ (Reprinted with permission from The Annals of Pharmacotherapy, copyright 2001, Harvey Whitney Books Company.)

Table 1

Dos and Don'ts for Scientific Manuscript Writing

Section	Do	Don't
Getting Started	Find a mentor	Write down to your readers
	Do a thorough literature search	
	Make an outline	
	Think about journals to publish in	
	Think about “so what?” question for conclusion	
Abstract	Write last	Include any data not found in the paper
	Be concise	
Introduction	Write in present tense	
	End with study purpose	
Methods	Include details of what was done	
	Write in past tense	
	Include preliminary results or pilot studies	
	Describe the statistical analysis	
Results	Write in past tense	Include citations or interpret your results
	Include figures and tables that can be interpreted on their own	Repeat data found in table in the text
	Use “significance” to mean statistical significance	
Discussion	Relate findings to your hypothesis	Criticize other published work
	Interpret your statistical findings	Come to conclusions not supported by your data
	Use past tense for your study but present tense when discussing other studies	Use statements such as “This is the first study to demonstrate...”
	Compare and contrast your results to other published work	
	Discuss the importance and clinical relevance of your findings	
	Discuss limitations and strengths	
	Make suggestions for future research on your topic	

Table 2Examples of Elements to Include in a Well-Written Scientific Manuscript⁴¹

Section	Element	Example
Introduction	Purpose	"The specific aim of this article is to evaluate outcomes for the fingers in terms of ulnar drift, extension lag, and MCP joint arc of motion. We hypothesize that the ulnar fingers will have less improvement, marked by greater ulnar drift, extension lag, and less MCP joint arc of motion than the radial fingers."
Methods	Controlling for confounding variables	"The following exclusion criteria were established because they are potential factors that would confound the homogeneity of the study sample: health problems that would prohibit surgery, extensor tendon ruptures in the study hand, swan-neck or boutonniere deformities that would require surgical correction, previous MCP joint replacement, and the initiation of disease-modifying antirheumatic drugs within 3 months of enrollment (because of the potential increased risk of surgical infection and the possibility of confounding the functional outcomes)."
Discussion	Major findings	"Our hypothesis that the ulnar fingers would have worse outcomes was not proven by this study. We found that the ulnar fingers have much better correction than the radial fingers."
	Interpretation	"In this study we found that, 1 year after SMPA, the ulnar fingers had similar ulnar drift, less extension lag, and better MCP joint arc of motion compared to the radial fingers. The ulnar fingers had worse preoperative measurements but improved 1 year after surgery to similar or better outcomes compared to the radial fingers. Compared to other SMPA studies with longer follow-up, we achieved arc of motion in the radial fingers that was in the lower end of the range of results and arc of motion in the ulnar fingers that was in the higher end of published ranges."
	Clinical relevance	"The importance of this study is that hand surgeons, when reconstructing the hand of a patient with RA, can assuredly indicate to the patient that all the fingers will have an equal chance of being aligned by the SMPA procedure."
	Limitations	"However, a limitation of our study is that the homogeneity of our patient sample decreases the ability to generalize our results for those with less severe deformities. Furthermore, our follow-ups are the shortest compared to other published studies and it is possible that, over time, the ulnar fingers might experience worse outcomes."
	Strengths	"Our study differs from other published studies in that all patients were followed up prospectively with both pre- and postoperative measurements. Patients were enrolled into a strict protocol in which follow-up occurred 1 year after surgery. Because of the retrospective nature of most other studies, the follow-up periods varied as much as 15 years. In this study, patients were recruited from 3 sites, which allowed us to increase our sample size. The protocol was standardized across sites to ensure consistent measurements. The patients included in our study might represent a more homogeneous sample because they all had RA, all had similar hand deformity, and all had 4 joints replaced. Other published reports did not indicate such strict criteria for study entry."