Writing and Publishing Your Research Findings

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Abstract: Writing clearly is critical to the success of your scientific career. Unfortunately, this skill is not taught in medical school or postgraduate training. This article summarizes our approach to the writing and publication of your research. Here we focus on empirical or experimental reports of translational and clinically oriented research. We review the process of choosing what to write, how to write it clearly, and how to navigate the process of submission and publication.

Key Words: medical writing, career development

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INTRODUCTION

Articulate Writing Is Critical to Scientific Success

This article summarizes material presented in a course that we have taught at the University of Texas Southwestern Medical Center at Dallas. The material is a synthesis of material from a variety of sources (see References), to which we have added our own, sometimes idiosyncratic, suggestions for developing peer-reviewed journal reports of clinical and translational research. We particularly want to acknowledge *Essentials of Writing Biomedical Research Papers* by Mimi Zeiger[1] at the University of California at San Francisco, whose book we highly recommend.

Writing clearly and accurately is critical to the success of your scientific career. If you do not write clearly, your article will not be cited. If you are not cited, you will not get promoted. If you do not get promoted, you will not have a job. Writing clearly to maximize your likelihood of being cited by others is key to your scientific survival. Published research is your only final product. A poorly written report could mean that you have wasted years conducting your study, because what you have done will not be cited or known. As such, it will not impact the field. The threat of career failure should be a powerful motivator for writing clearly, as is doing the very best science that one can.

Each article tells a story, but there is no "one true path" to writing. We each learn how to use our talents, overcome our deficiencies, and develop our skills differently. Each article we write is less difficult, but none is ever easy. To avoid feeling overwhelmed by the effort, we suggest that you approach writing as a series of questions to be clearly answered. What was the research question? Why does the answer matter? What was done? What was found? Has anyone else found that (or not)? What might it mean? What limitations or qualifications apply to the findings?

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Define What to Report

What are you going to write? Obviously, the primary paper focuses on the main hypotheses that you tested. But there may be several secondary hypotheses and maybe a couple of tertiary papers that are hypothesis generating. But be careful. Do not write trivial papers (third-rate papers with too small samples). They take too much time, are not cited, and have minimal to no payoff.

So, consider at the outset what aspects of the project are to be submitted, where, and in what order. What is the primary paper? Are there secondary papers? Clinical investigation often requires many people, so consider which colleagues might like to take the lead on a secondary paper. That is, depending on the size of the study and the contributions, needs, and expertise of your multidisciplinary research team, think about additional papers for others than yourself.

Getting Started

How often have you heard, "I have writer's block"? What does that mean? Everybody who has attended medical, dental, or nursing school can write. Thus, "writer's block" is a fiction—an excuse. The underlying fear may be that either one cannot think clearly enough to be able to say what was done (in which case, a career change is indicated!) or one is afraid that the product will not be "good enough" and therefore procrastinates.

To overcome "writer's block," simply realize at the outset that most of the words in the first draft will not make it to the final draft. Once you have something on paper, however, you can edit it—repeatedly. To get it on paper, dictate, type, or handwrite it (whatever is fastest for you). We recommend that you start with an outline. The outline is straightforward: title, abstract, introduction, methods, results (with tables and figures), discussion, conclusions, references, acknowledgements, and disclosures. Then write a topic sentence for each paragraph in each section. The outline and the topic sentences should take you about an hour-and-a-half to write. Then start to write each paragraph in the 4 key sections (introduction, methods, results, and discussion).

One place to begin is with the protocol that you followed to conduct the study. The protocol contains the aims, hypotheses/questions, rationale, and methods. Thus, the protocol is the basis for the first drafts of the introduction and methods. You may need to update the significance (to beef up the introduction) and to cite the newest relevant literature. Borrow from what you have done to begin.

Recall that journals limit articles to 3000 to 4000 words. If each paragraph has 200 words, you have to write 18 to 20 paragraphs (Table 1). The introduction has 3 to 4 paragraphs (never longer than 2 manuscript pages); discussion has 5; results typically has 4 to 6, depending on the number of questions; leaving 5 to 6 for methods. Once you break it down this way, it does not seem so bad.

Prepare to Spend Time

Realize that writing takes a lot of time. You must set aside uninterrupted time, which in our view is best inserted between

TABLE 1. The Main Elements of a Manuscript

Elements	Length and Limits
Title	<12 words
Abstract	250–300 words
Introduction	600 words (3–4 paragraphs)
Methods	3–4 pages
Results	2–3 pages
Tables and figures	≤5 combined (see journal style)
Discussion	3–5 pages
References	<40 (see journal style)

other activities that do not involve writing. Write for a while, then stop and leave it alone. When you go back later, you will be more objective and be better able to edit your prior work. Too many people frustrate themselves by expecting to write up 4 years of work in 4 weeks. That is not realistic, especially if you have not written many prior papers, if you have other duties, or both. So think about what you want to produce and divide the work into "doable" pieces (eg, the major sections noted above). Allocate a fixed amount of uninterrupted time each day to work on 1 section at a time to assemble these pieces without regard to how well it is written and without thinking about references. Simply tell the story.

Tell the Story

Look at the big picture first. Recall that you know more about what you have done than anybody else, so do not get nervous. You know the story—what you did and why you did it. Writing the first draft should not be a big thing. Polishing your drafts is where the time is.

The most important thing is to tell the story. Most people get stuck in the details and lose track of the story. Readers want to know what the issues were, why they matter, and what questions were asked (introduction). Then how were the issues addressed, questions answered, and hypotheses tested (methods)? Next, what were the answers (results)? The results section is divided into subheadings, often based on the questions or hypotheses at the end of the introduction. A table or figure should accompany each question. Finally, what do you make of the results (discussion)? These are the major sections of each empirical report for scientific journals (Tables 1 and 2).

Recall for Whom You Are Writing

Do not write your paper for scientists, colleagues, the promotion and tenure committee, or your department chair. Tell the story as if you were talking to somebody who is not an expert in your area. If you make the article that simple and straightforward, readers will be able to understand what you did and be able to cite the paper. If you use a lot of jargon, compound sentences, or obscure wording, only you and your coauthors will actually know what you are saying.

TABLE 2. Elements of the Story Line

Element	Place in the Manuscript
Gaps in knowledge	Introduction
Hypotheses or questions addressed	Introduction, methods
What was done to test the hypotheses or answer the questions?	Methods
The answers to the questions	Results
The meaning of the answers	Conclusions

TABLE 3. Common Reasons for Rejection or Revision

Introduction too long
Methods lack detail
Results jumbled
Figures and tables not clear or not useful
Discussion too long
Confusing or inconsistent terminology
Manuscript too long (wordy)
Lack of flow
Does not "tell the story"

Be Pithy

Table 3 highlights the most common reasons for rejection/revision. Most of these issues can be addressed by being pithy (succinct but full of substance and meaning) and consistent. Sentences should be simple: subject, verb, object, period. Whenever possible, avoid compound sentences. Do not change terminology throughout the paper (eg, do not interchangeably use subjects, participants, patients, or volunteers). Readers will wonder why you changed the names. Whatever word or phrase you use to describe something, keep using the same term. This is not an English essay or creative-writing class. A scientific article uses an expository writing style—it simply tells the facts. The reader needs specificity, clarity, and brevity—not engaging phraseology. Be very specific. Avoid general statements such as, "The patients improved." What does that mean? Better to say something like "Patients in group A had a greater reduction in X than did patients in group B; test, *P* value (Table X)." Finally, physicians tend to be pompous in their style of writing. Avoid this; it prevents clear communication. Invest in a guide to clear medical writing to help.[2]

Let us now consider each element in a manuscript.

THE MANUSCRIPT

Title

The title should have 12 words or fewer (pithy). Notice that movies do not have long titles. *The Fugitive*. Not *Escaping Jail Following an Unfair Conviction in Chicago*. Just *The Fugitive*.

Do not say: "A study of X." Of course it is a study. That wastes words. Begin the title with a key word. Be to the point. Grab the reader's attention. Table 4 lists characteristics of a good title.

TABLE 4. Characteristics of a Good Title

Snappy, simple, short, concise, specific
Easy to understand
A headline (but an accurate promise)
Interesting, "a reader grabber"
Nondeclarative (do not give the conclusions)
Begin with a key word
Consider a question
No abbreviations (unless common to the journal)

Abstract

There are 2 kinds of abstracts: structured and unstructured. Structured abstracts have distinct subsections: objectives, methods, results, and conclusions (these may vary by journal). Unstructured abstracts contain the same information, but are just 1 long paragraph.

Most people do not read an entire article. Everyone reads the abstract. So whatever is in the abstract is what everyone thinks is in the article. Therefore, it is critical to edit, polish, and perfect the abstract, because it is almost the only information that readers will take home.

What is the state of knowledge? What was the question (background)? What did you do and how did you do it (methods)? What did you find (results)? What is the bottom line (conclusion)? That's it!

We like to write the abstract first because it forces us to give the 10-second version of the paper. Then we polish it repeatedly after we write the article. The abstract will change a lot—often not substantively, but especially in terms of clarifying and simplifying the presentation. If you write your abstract first, you must ensure that it matches the final manuscript.

Introduction

At the beginning, tell the readers the problem (Table 5). What do we know and what do we not know? Why does this matter? Then, what are the questions or hypotheses to be addressed or tested? What, in brief, was the approach?

The introduction should hook the reader. Paragraph no. 1: What is known? For example, "Diabetes is bad news, especially when it is associated with fatty liver." Paragraph no. 2: What is unknown? For example, "We do not know how to treat patients with this complication."

Paragraph no. 3: What is the question or hypothesis? "This study was conducted to determine whether A is better than B in improving fatty liver in patients with diabetes." What was done? "We addressed this question by conducting a randomized controlled trial of A versus B in diabetic patients with fatty liver." Be sure the introduction states your questions or hypotheses. End the introduction with a statement of your hypothesis: "We hypothesized that A was significantly better than B at decreasing fatty liver because…." Bingo, the introduction is done.

The introduction is NOT a literature review. Do not overreference. Seven to 10 references are plenty. Less experienced writers seem to feel the need to cite the entire literature before getting to the methods. Do not. Everybody will trust that you can read. What they want to know is what was the issue. Why is it important? How did you approach the problem?

Methods

A poorly written methods section is a major reason for rejection. Be specific. Give details. Readers must know what you did. Remember, someone may try to replicate what you did! If the replication fails, your credibility is questioned. Give enough detail to ensure that another scientist can replicate exactly what you did. Give no more detail than is necessary, but give all the details that are required for replication.

TABLE 5. The Introduction: Start Broadly, Then Narrow

Paragraph 1: What is known
Paragraph 2: What is unknown
Paragraph 3: What is the study question
Paragraph 4: What, briefly, is the experiment

TABLE 6. Common Elements of the Methods

Overview of study design
Participants (how gathered or recruited)
Eligibility (inclusion and exclusion)
Randomization and blinding
Interventions
Adherence and compliance measures
Concurrent treatments
Measurements
End points (outcomes)
Analyses

The methods section is typically in chronological order. What did you do first? Then what did you do? Methods can be dense. Use subheadings in the text to guide the reader. Table 6 lists common elements (subheadings) of methods.

First, provide the study overview. What was the design? When was the study done? Where was it done? For example, "We conducted a multicenter randomized clinical trial of drug A versus placebo for 6 months in participants with type 2 diabetes and fatty liver." This brief, 30,000-ft overview primes the reader for the dense (but clear) text that follows.

Then provide the details (Table 6). How did you recruit the sample? Consecutive? When you felt like it? How did you define who is eligible? When did the study start and stop? And so on. Do not include results in the methods section. The rules for obtaining the sample are in methods. The sample that you obtained by using these rules is described in the first paragraph of results.[3,4] It is very important to say how the current sample relates to other reports of the same or related samples. Be very clear about whether patients in your study were or were not included in any prior reports. People doing meta-analyses or literature reviews, for example, must know whether the present sample is distinct or not from other samples. Surprisingly, you often cannot tell whether 2 reported samples are partially overlapping, the same, or distinct.

Describe where the study was conducted. Define all the variables used in the report, but none of the variables not in the report. Sometimes you might collect variables not included in this report. If they are in another report, you do not have to put them in this report.

What was the rationale for the randomization? Was it stratified? Was it computer based or did you use a table? Did you randomize in blocks? What was the informed consent process? Was there institutional review board or data safety monitoring board oversight? Were measurements blinded? Who was blinded and how?

How did you deliver the treatment of interest? How often were they treated? Who provided the treatment? How else were they managed? Could there be home visits? Could there be extra visits? Be very specific.

Did you assess whether patients adhered to treatment? If so, how? Did you ask them, count pills, or use MEMS caps?

How did you ensure that the people who delivered the study treatment did what they were supposed to do? Was there a manual? Was there quality control?

How were concomitant medicines managed? What rescue treatments or other efforts were used when patients worsened?

What were your outcomes or end points? Which was your primary outcome? Which were secondary? Who measured or obtained the end points? How? When? Was there quality control for these measures? Who did it? How? How often?

What sample size did you use? What kind of difference did you expect? What difference was expected? Did you power the study to detect this difference? What is the power? Why did you choose the statistical tests you did? Who did the analyses? Finally, it is very important that your coauthors see the data and have some discussion with the statistician so they really understand how the study was analyzed. You have to assume that your coauthors are going to make slides from this study and present it somewhere. If they do not understand the analysis, the audience will not. And they will be misinformed, unfairly judge your study, or both.

Results

When writing the results, we first build the tables and figures. Then we write the text to tell the story, answering the study questions, around the tables and figures. The text of results is often brief because the tables and figures provide the findings. Be pithy. The less you elaborate, the clearer you will be. You want the bottom line to be very, very clear. Remember, results is for the results. The introduction tells readers why you did the study. How you arrived at the results is in methods. What the results mean is in discussion.

Start with the results of the most important question, then the second most important, and so on. Or organize the section chronologically. Use subheadings to denote each question or section. There should be no interpretation of findings in results. Make the results exciting, but do not hype. Table 7 lists important points to consider when writing this section.

If your patient sample is not extremely simple in composition, use a CONSORT chart.[3,4] This chart explicitly and clearly shows how you obtained the evaluable sample. It will save you many words. Journals may require this chart, especially for clinical trials. If 2 (or more) groups were compared, describe and compare these groups at baseline. Serious adverse events, tolerability, attrition, and dosing may be in subsequent tables. Describe patients sensitively. People are not schizophrenics or diabetics. They are patients with schizophrenia or diabetes. They are participants, not subjects. Why participants? Because they chose to participate by giving consent. Subjects, such as rats, do not give consent.[5]

It is critical that the tables and figures carry the message. Do not repeat in the text what is in the tables and figures. Why? People can read the tables and figures. Use the text to direct the reader to the tables and figures. A sentence or 2 in the text to draw attention to a few key findings might be useful in the results section, but do not comment on every item in each table.

Tables and Figures

Figures and tables should stand alone. That is, each should be understood without reference to the text. The text simply alerts the reader when to look for them. So, if you use abbreviations or acronyms here, spell them out in the footnotes and legends. A figure has a title and legend that explains it; a table has a title and footnotes, if necessary, but no legend. Each figure or table should be on a separate sheet of paper. Remember, readers may use your tables and figures as slides. Make them clear and self-contained so that the slide has meaning.

TABLE 7. The Results

Order results from the most to least important question
Order results chronologically (as they were performed in the experiments)
Key findings (from each study question) should be in tables and figures
Include final sample size and baseline characteristics (not in methods)

TABLE 8. Elements of the Discussion

Synopsis of main results (order by study question)
Compare results to the literature and explain differences
Clinical and theoretical implications of findings (that is, so what?)
Limitations to study methods, certainty of results, and generalizability
Pithy conclusions

Provide clear names for each column of your table. The study variables (eg, age, sex, severe adverse events, remission rates) are typically in the leftmost column, and each defines a row. The data are in the columns to the right. Avoid vertical lines in tables. The rows should have few to no horizontal lines.

Whenever you use a percentage in tables (and elsewhere), give the numerator and denominator so the reader can see how you derived it. We like to put significant *P* values in bold, but always follow journal style. Give the actual *P* value, not "NS" or "<0.05." Only use decimal places that are informative. For example, nobody knows what 48.134 years of age means. Report 48.1 years. Keep it simple.

Good figures are worth a thousand words and probably several tables. Figures should show your primary comparisons. The reader should be able to look at the figures and tables and know what the questions and answers are without reading the text. Avoid 3-dimensional figures and gratuitous color and shading. Most of the ink used to print your table should represent your data, not explanatory or decorative material. Creating clear and meaningful figures is a skill one learns. Practice it. Texts by Tufte[6] and Goodman and Edwards[2] can aid you in good design.

Discussion

Next to the abstract, we find the discussion to be the most difficult part to write. We may be excited about what we have found and have lots to say about it. This may make the discussion wander. Here is a way to organize the discussion (Table 8).

The first paragraph summarizes what you found. "This study was designed to determine whether A is better than B with regard to X. We found A was better than B in terms of tolerability, side effects, and remission rates, but not in terms of Y." If there was a second question, then the findings follow in the same first paragraph. You told them the questions (hypotheses) at the end of the introduction. Now, you summarize the answers. Avoid repeating the results; you just stated them.

The second paragraph of discussion addresses the question: "Has anybody else found anything like or different from what you found?" That is, how does it compare to the literature? If your findings are different, why? Is it the method, the sample, or measurement differences?

The third paragraph addresses the theoretical or clinical implications of the findings. What do these results mean about the utility or mechanisms of the study treatment or the pathophysiology of the disease being studied?

The fourth paragraph highlights limitations (and strengths). Limitations commonly include design, methods, generalizability, and internal validity. How certain are you about the results? A small study cannot be generalized. Measurements may have been too infrequent or too insensitive to detect an effect. Attrition may have been high. How does that affect certainty? Do

not overstate the certainty of your findings. If you do not acknowledge the limitations of your report, the reviewers will make you. This is low-hanging fruit. Do not give reviewers the opportunity. Be honest, but this is your chance to frame the limitations in the best light. Remember, all studies have weaknesses. Do not feel embarrassed to list and discuss them. If your study has particular strengths, you may also highlight them here. This may soften the blow of the limitations.

Conclusions are pithy. Three sentences are enough—only 1 paragraph. A conclusion is: "A is better than B for these kinds of patients. This conclusion is limited by X and Y." Some journals like you to suggest policy, economic, or practice implications—this is your final sentence: "Since X is better than Y and we have no other treatment for these patients, we recommend despite the limitations of this first trial that X might be a better treatment, but confirmatory studies are needed." A common phrase that ends the conclusion is "more studies are needed." Do not use it. More studies are always needed. Instead, state what studies you think are needed.

References

Leave the insertion of citations for the end. Where do references come up in the article? Largely in the introduction (7–10), methods (6–9), and discussion (15–20) (maximum, 30–40). The few references in the introduction should help lay out the problem and say why it is important. An introduction is NOT a literature review. The references in methods refer to measurements or techniques described in detail elsewhere. You do not have to describe them again; reference them.

If you use someone else's idea, give appropriate credit. Remember, that person could be a reviewer. You do not have to cite everything, just that which is immediately relevant to support your point. Rely on peer-reviewed literature, reports, and reviews.

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Disclosures

Journals have different but increasingly strict rules about disclosure. Follow them closely. If you are in doubt about a relationship, disclose it. Only underdisclosing, not overdisclosing, will embarrass you.

GETTING IT PUBLISHED

Authorship

This is a thorny issue. If you are the principal investigator, we strongly advise that you meet with your study team when you launch a study to talk about authorship. Consider who will write up the primary question and key secondary questions. Talk it through early, so everybody knows the expectations from the beginning. This is especially important for junior faculty who need to know, after spending a couple of years on the study, what are they going to get out of it.

Who is supposed to be an author? Most journals have specific requirements. Those who have contributed to the design and execution of the project and helped in developing the manuscript are logical possible coauthors. Just raising funds or being the chairman of the department does not qualify (use the acknowledgements for these individuals).

Typically, hired or support staff are not authors, but there may be exceptions, depending on their contributions. Students or fellows can certainly qualify if they make a substantive contribution either at the beginning, during the data analysis, or with the writing.

For large or multisite studies, it is extremely important to have a publication committee. Try to get on the publication committee. Some studies base authorship on enrollment, scientific expertise, execution of the study, and leadership. Have these discussions early and be up-front about authorship. Most people do not like to talk about authorship (as they do not like to talk about their salary). But you cannot be shy. Younger faculty need to be first, second, or third author. Beyond third author, you are "et al." Last is for senior authors.

Rewrites

Rewrites are critical. There are many reasons to rewrite (Table 9). We suggest that you go after specific targets with each rewrite. If you have coauthors, use them. The first author should not have to write everything if coauthors are to merit the recognition. Once you get a draft, share it with coauthors and direct each one to a task. "X, please revise the introduction." "Y, please revise the methods." You distribute the work and have it come back to you. You have final editorial say as the first author. It also helps you to see how your coauthors interpret what you have written, what questions they have, and what changes they suggest.

When you ask coauthors to rewrite, set the time frame and tell them exactly what you want them to do. "Please give me feedback on the results section. Please review and revise within 7 days." Everybody has a large pile of things to do. Without a scheduled time limit, the article goes to the bottom of the pile. Rewrite 1 section at a time. Sequence the writers, so somebody does one section and someone else does another. But remember, the manuscript should not read as if there was a different author for each section. So, you have to ensure that the entire text "flows" and is stylistically consistent.

Table 9 shows areas of attention for rewrites. Shorten the introduction. Polish the abstract. Shorten the discussion. Double-check the methods to be sure the words are totally explicit, specific, and detailed. Delete jargon. Delete words. Make sure your tables and figures, if read alone, tell the results all by themselves.

Outside Readers

Once you and coauthors have written the article to its "final version," send it to 2 people who have no idea what you do, but who are intelligent and can communicate. They do not have to be experts in your area. Ask them to proofread the paper. Then ask them to tell you in their own words what you found. That way you will know whether they got the message.

TABLE 9. Reasons to Rewrite

For organization and flow (the story)
For inclusion and exclusion of material
For clarity and necessity of tables and figures
For specificity and clarity of exposition
For wordiness, jargon, complex sentences, and phrases
For length
For references

Choosing a Journal

In choosing a journal, select one that is highly regarded with a high citation index. The journal content should match what you are reporting, so the readership will be interested in what you have to say. Some journals restrict length a lot—some less so, which might be a consideration in choosing a journal. Pick a journal as your first target that is bit of a long shot (sort of a stretch), but have in mind a second choice if the first rejects the paper. It is helpful if your second choice has similar requirements as the first. For example, you do not want to be limited to 4000 words for the first journal but to 2500 words for the second.

Rejections and Resubmissions

Rejections and negative reviews can be very frustrating. You may even feel angry or defeated. This is normal. Read the reviews through once, then put them aside for a while. If you are given the opportunity to resubmit, do not formulate your responses yet. Return several days later and read the reviews again. You will have a clearer mind then, and you will be less likely to respond angrily or with condescension. Some rejections are valid. Some are due to misunderstanding, which means that you were not clear. The reviewers took the time to read your article. If they did not "get it," it is your writing.

Sometimes the editorial response highlights the problem and seems to say either "Please fix this and resubmit" or "It's a long shot, but we'll re-review it if you want to try—no guarantee though." Always respond item-by-item to each of the reviewers' comments in a detailed letter. Be careful with your tone. A negative tone in your responses will work against you. We like to write the response letter before revising the paper. Think through everything you want to do, then revise the paper and show your changes. Always include your coauthors in this process, because they are signing off on what you are resubmitting.

CONCLUSION

We hope this synopsis is helpful. It took 15 drafts. It could still be better. So, writing is never easy. But what you want to get back from the reviewers is "This is a clearly written, succinct report of X. I have some remaining questions…." No report is perfect. Recall that the reviewers are your helpers, but they cannot help improve your manuscript (or science) if you have not been clear in telling the story, specific in describing what you've done, and to the point throughout the paper. Good luck!

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