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GUEST EDITORIAL

Kipling's Guide to Writing a Scientific Paper

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The generally accepted structure of a scientific paper is four sections, an introduction, a methods section, the results, and a discussion. This so-called IMRaD format is, with a few small variations, found in most research articles in biomedical journals. However, as a guide for someone writing up research data for the first time, it is far from complete – for example, there is no T for title or even S for summary. Nor does IMRaD explain what belongs in which section and how much should be included in or excluded from any section. As a supplement to, but not a replacement for, IMRaD research-workers could bear in mind the "six honest serving-men" of the poet Rudyard Kipling. These writer's servants are called *What, Why, When, How, Where,* and *Who,* and they can be applied to all parts of the paper from its title down to the tables.

Key words: *authorship; journal article; journalism, medical; periodicals; science; writing*

What is IMRaD?

The journal *Nature Medicine* prints the methods section last and in smaller type whereas *Science* buries explanatory footnotes within its reference lists. There is nothing rigid about the way research articles are printed. The sequence of having an introduction followed by the methodology, then the results and lastly the discussion, the so-called IMRaD format, may have stood the test of time but has it become a straitjacket? A *Lancet* editor, pleading for pluralism, referred to "temples of knowledge erected on the shaky pillars of IMRaD" (1). IMRaD is certainly incomplete. For example, it says nothing about the title or even the summary. It is tidy, perhaps too tidy (2). Research is a human activity in which things do not always go as intended yet, via IMRaD, the paper version describes perfectly planned and beautifully executed projects free from all accidents and human error. Nor does IMRaD tell the writer how much to put in or leave out or what level of reader to aim at.

To complement IMRaD, I suggest that writers remember a few lines from the British writer Rudyard Kipling (1865–1936). Kipling is still known for *The Jungle Book*, verses such as "If" and one or two other pieces but he is no longer fashionable as a writer of either poetry or prose. Nonetheless, he could be a sharp observer and he penned phrases that are now part of the English language (3). For example, those seeking to influence events in Afghanistan in the last months of 2001 would have done well to read Kipling's lines:

"At the end of the fight is a tombstone white
with the name of the late deceased
And the epitaph drear: 'A fool lies here
who tried to hustle the east'."

Gems of wisdom also lie in the *Just-So Stories*, and Kipling's "The Elephant's Child" can help the novice writer build on the IMRaD structure:

"I keep six honest serving-men
(They taught me all I knew)
Their names are What and Why and When
And How and Where and Who"

Courses in journalism teach items of this sort as the basic elements of good reporting. WWWHWaW can be just as useful in the world of scientific writing, and I will apply this tool to all parts of a scientific paper, from title onwards, and show how it can help writers to avoid some of the common mistakes that editors observe. But let us begin with the traditional IMRaD.

WWWHWaW Applied to IMRaD

Introduction

Before you first put pen to paper or lay fingers upon a keyboard ask *Why* you are writing (Table 1). The honest answer – and, remember, Kipling's aides

were "honest" – may be that a paper is required for reasons to do with career advancement. The more usual responses are that you have interesting results to share with others and/or that research is nothing until it is published. But why write now – in other words, *When* does a study merit reporting (Table 1)?

Table 1. Applying Kipling's helpers to traditional IMRaD

IMRaD section	WWWHWaW questions
Introduction	Why are you writing – and why now? Who are you writing for? Who is doing the writing? What problem are you addressing; what is the background to it; and what is the prior hypothesis you were testing?
Methods	How did you do the study? What materials did you use or what types of patient did you study?
Results	What did you find? How much can you include? What belongs in tables or figures and what is better in the text?
Discussion	What are the strengths and weaknesses of your study? How do your findings fit (or not) with other published evidence? Where now -ie, what comes next in your research and has your prior hypothesis stood up to your test of it or should you modify it or even abandon it?

A common fault on timing relates to the study design. If you have done a power calculation, a statistician will have asked you what difference between test and control groups will be important clinically or biologically and then estimated the numbers of patients or mice you will need. With some randomised controlled trials it may be necessary to report early, before the trial is over – perhaps because a planned interim analysis has suggested that it would be dangerous and/or unethical to continue. Usually, however, a preliminary report should be restricted to an interesting incidental observation in a study set up for some other purpose. Phased reporting of the same study is, at best, confusing, especially to those who have to draw conclusions from several different projects (4). Sometimes this practice is referred to as *salami* publication, after the name of an Italian sausage thinly sliced. You will also hear the phrase "redundant publication", a term applied to the even worse practice of true duplicate publication (5).

A more important *Why* relates to your introduction. *Why* did you do the study? At this point you will need to bring in a *Who* as well (Table 1). For whom are you writing – is it your peers, fellow experts in a narrow specialty who will instantly recognise the problem you have looked at and understand the technical language you use, or is it a less expert reader, who will need assistance? (A seventh Kipling helper here might be *Which*, which journal are you submitting to; and that decision also affects the level at which your paper is written or rewritten.)

So, your introduction should set the scene, and that scene should be the situation when you began the research. For example, it seems illogical to cite in the introduction references not available when the study was conceived. A good, up-to-date review article, which can economically introduce the subject, would be an exception to that rule. Amazingly, introductions will sometimes include the conclusion of the article. Avoid that mistake. End this section of your paper with a clear statement of the hypothesis your study set out to test. By all means read about the hypothetico-deductive system (6), but in print, keep it simple, and in doing so avoid *post hoc* adjustment; do not rewrite your idea in the light of what you found. Two paragraphs or at most three for your introduction should be enough.

Methods

The methodology is Kipling's *How*. In the physical sciences there is a tradition of methods being given in great detail so that others can repeat an experiment exactly. For example, you will read details of the glassware used and the level of purity of chemical reagents and the company you bought them from. This can also be important in medicine, obvious examples being the sequences of DNA probes and the precise conditions of polymerase chain amplifications. However, in clinical studies exact replication is almost impossible since patients are neither glassware nor guinea pigs so, depending on the journal, it may be a good idea to submit for inspection by editors and referees, more methodology than you really expect to see published.

However, methods sections in medical journals are growing longer, especially in general journals where several specialist interests may be competing for space for their methodological detail. A separate section for statistical methods is common nowadays, and I cannot emphasise enough the importance of getting statistical advice before the research begins rather than when the data have been collected. Also contributing to increasing length are the many reporting guidelines (and pressure groups arguing for their use) for things like nutritional science, clinical trials and meta-analyses, and molecular genetics. If you have a histopathological colleague, he or she will be fussy about staining conditions and magnifications; radiologists have their demands too. How much methodology to include and when to resist the suggestions of specialist colleagues will depend on what the journal's readers expect, and that can be a matter for negotiation with the editor at the revision stage. An invitation to revise, as opposed to a straightforward, unconditional acceptance, is usually the best you can hope for.

In studies involving patients it is usual to include under methods ethical committee approval for the study and information about informed consent.

Results

This is another section of your paper where sacrifices will have to be made. You are always going to have more data than you can publish. Few journal editors or their readers want to see raw data. Also, you will have many measurements, especially in clinical studies, that are routine tests (e.g., automated analyses on blood samples) and add nothing to your study. However, raw data should be accessible and should be stored. An editor or journal referee may ask for

data, and after publication other researchers may ask for this information.

The usual way of summarising large data sets is by tabulation of statistically summed information or by the use of figures. Figures may be illustrative. If there is room just for one or two examples these, strictly, ought to be chosen at random but it is only human for researchers to pick their best western blots or their clearest radiographs. Or figures can contain more solid data. However, figures are not well suited for data retrieval especially when log scales have been used, and scatter plots (data on individual mice or patients) can be too busy. How to present data represents a compromise between clarity and economy. You will not please everyone, not even yourselves probably, with this compromise but do avoid repetition in text, figures and tables.

Discussion

There is no rule that says that the discussion should occupy a fixed percentage of the total article length, but this section, just like the one on methods, is getting longer. The proportion might be small in a purely methodological paper while an article recording something controversial in public-health terms would need to have an unusually long and careful discussion of the findings. All the same, as with any writing, discipline is required, and Kipling can help.

The key questions here are a *What* and a *How* and a *Where* though you may not be able to answer them in only three paragraphs. *What* were the strengths and weaknesses of your own study? It will have weaknesses. Something may have gone wrong (e.g., you were unable to recruit enough patients or crucial samples went missing) or perhaps a better method has been described since you set up your project. Then *How* do your findings fit in with work published by others? You will not be able to cite everything that has been printed on the subject, and many of the hours you diligently spent in the library or on the Internet must go unacknowledged. Finally, *Where* is this line of research going next? This is when you face the challenge of deciding whether your original hypothesis is still standing. Discussion sections can drag on and the above three restraints may prevent that happening.

Just as bold statements such as "This drug will safely cure all patients with that disease" are best avoided in medical writing, you should avoid being overcautious too. This means not using too many qualifying words such as "possibly", "maybe", "perhaps". Some people, even some editors, think that these words are the mark of true scholarship; good academics, in other words, should never make statements that lack an escape route. Think of caution another way, a non-Kiplingesque, mathematical way. Suppose that any qualifying word dilutes the certainty of a statement by one-third. The phrase "We tentatively suggest that X may possibly cause Y" contains four diluents and their effects are multiplied. The certainty of "X causes Y" is diluted with every step to 2/3rds certain. You finish up with a very uncertain 16/81sts, which is only 20% sure and not what you meant.

What IMRaD Does Not Do

IMRaD does not say anything about a paper's title, authorship, or summary. The conclusion, acknowledgments section, and references are neglected too. As an acronym TASIMRaDCAR will never achieve IMRaD's fame but we can still bring Kipling's helpers to bear on the new components (Table 2).

Table 2. Applying Kipling to TASCAR, the non-IMRaD parts of your paper

Section	Notes
Title	How long; how many parts; declamatory (or not)?
Authorship	Who is best defined in advance; what does "authorship" mean; how many?
Summary	What structure; where to place it; how long?
Conclusion	Who needs one?
Acknowledgments	Who should be thanked; who paid; who has conflicts?
References	How many; what are they for; how to set them out?

Title

Journals will often have their own preferences. They may, for example, not like declamatory titles, extreme examples of which would be "The cause of A is B" or "C is the drug of choice for..."; they may hate two-part titles; or they may not care how long a title is. At least titles are negotiable, so you, as author, need to think *What* the title is meant to do and *Who* are you writing for. Read the journal and familiarise yourself with its approach to titles. Remember with two-part titles that the second part may be omitted in citations and by searching services so it is sensible to ensure that keywords are in your title. Some journals will ask you to provide keywords on the title page of your article.

Authorship

This has become a serious *Who* question, especially in medical journals. A definition by the International Committee of Medical Journal Editors (ICMJE), though useful (7), is now generally accepted to be too strict, and some journals are showing more interest in publishing the contributions that authors made to the study and resulting paper (8,9). In May 2000, the ICMJE relaxed its position a little. Deciding on authorship before the study begins is a good idea though in a study that takes years to complete, the research team may change significantly. All "authors" should have seen and approved the final version as submitted for publication, and whatever the journal's policy is, it is a good idea to agree as the study progresses on what roles deserve authorship as opposed to acknowledgment.

In some branches of physics no one seems to care about how many authors there are and hundreds are not uncommon. From a botanist came an ingeniously democratic method intended for deciding on authorship before writing begins (10) but this may also help to resolve disputes.

Summary (or Abstract)

Summaries and abstracts were different in times gone by but today the differences are blurred. Summaries used to be very short and they appeared at the end of the article. They lacked structure, said very little, and employed the passive voice ("were studied" and "is discussed") with little hard information. All that has changed. Today they tend to be structured more or less on IMRaD lines and they appear at the beginning. Often the abstract will be all that a literature search engine (e.g., the US National Library of Medicine's PubMed) will provide free of charge, and it is a sad fact that many readers will not persist beyond your summary. Summaries are therefore important. Always check that everything in the summary is provided in and is compatible with your text. The reverse – everything that is in the paper should be in the summary – is clearly absurd. However, in the necessary compression you must not oversimplify the message of your paper.

Conclusion

If your journal of choice prints conclusions, you should provide one. However, with modern summaries and disciplined discussion sections, a conclusion should not be necessary and many medical journals do not have them.

"Acknowledgements"

This section, almost always printed in smaller type than the paper itself, used to be very simple. Authors would thank their secretaries and one or two other people and mention who provided funds for the research, and that was that. Today, this tailpiece to a paper is expanding and acquiring a structure of its own, which is why I have used quotation marks around the word. For example, you need to ask, in thanking someone for what they did, if that contribution actually merits full authorship (see above). If authors' contributions are published, they will appear in or near this section, as will any authors' conflicts of interest, financial or other. Clinical research often depends on the generous but unrewarded input of doctors, nurses and other healthcare workers, and in former times this was often taken for granted. Today, thanking them by name in print is more than a courtesy; it is a good investment for future collaboration.

References

There are three basic ways of setting out references. The Harvard system with authors' names and the date of publication in the text and the reference list alphabetical by first author; the numbered list in which references numbers are given in the text and the list at the end of the paper follows the numerical order; and the hybrid alphanumeric system with a numbered alphabetical list resulting in non-sequential numbering in the text. Most journals (*Nature* and *Science* are exceptions) give the titles of papers cited.

Why do authors provide references and *What* are they for? If the purpose is simply to tell the reader which shelf in a library to go to, a very simple code (e.g., the international serials number for the journal, the volume and the first page) would usually suffice. In today's world of electronic access this is increasingly being achieved by the digital object identifier (DOI) for the article. In print such codes do not tell the reader who wrote the paper or how long it was and what its title was. These days, thanks to the activities of the ICMJE, there is a consensus that medical journals will be happy to look at papers in the ICMJE style (7), which is numerical referencing in the text and a listing with authors, title, abbreviated journal title, year, volume, and first and last page numbers. Journals may print references differently but that is their problem.

Errors in references are common (11). Even if they seem trivial they will look, to editors and referees, like carelessness. Never cite something you have not read. I once saw in the list for a paper on hepatitis B antigen (which was then called Australia or Au antigen) a paper from a metallurgy journal about gold, whose chemical symbol is Au. References need to be accessible and some journals do not allow references to conferences proceedings and abstracts and will have strict rules about "personal communications". Websites are allowed but their impermanence worries editors (12).

Instructions to Authors

The ICMJE's "Uniform Requirements" (7) is a useful guide but most journals have their idiosyncrasies so do read the information for authors, provided in the printed journal you have chosen and/or on its website (or on a compendium site, ref. 13). This advice will often go beyond pedestrian instructions such as "double-spaced typing on one side of the paper". For example, *The Lancet*'s guidance (14) explains what the journal's many sections are for and tells authors how their paper will be handled.

The Electronic World

By giving pointers to writing, using the device of Kipling's helpers to supplement the classical IMRaD model, I have tacitly assumed the printed word. Of course, you will be using a PC not a typewriter; you will be asked to supply a disc as well as printed copies; you may even submit the whole paper via the journal's website with no paper; journals increasingly use electronic means to referee papers and they almost always use electronic production methods. We are, after all, in the 21st century (15). However, the object of publication – to share with others the fruits of your labour and to do so in as clear and economical way as possible – remains the same whether we live in a paper-only world, an e-only world (the future, some say), or both together.

Do Not Be Afraid

Time and again, when I have given talks on editing and writing, in countries where English is not the first language, I have been asked questions that imply that the audience is afraid to submit to British and American journals or, worse, that the audience believes that the editors of those journals are biased against papers from such countries. Editors want to publish good work; research quality is the criterion,

and journals will want to help you if the underlying quality is good. Perhaps scientific writing should always be taught alongside seminars on research methodology. Good prose cannot correct bad work. Anyway, poor communication is not restricted to those who day to day speak a language other than English. English has become the common language of medical science, and many journals published outside the Anglophone world (e.g., the *Croatian Medical Journal*) now use English. However, authors should not be worried about "American vs British English". The differences are rarely important for scientific writing.

Here in further tables are a few hints for the non-English-speaker (Table 3) and some personal suggestions about the books that medical writers may like to have, in departmental or central libraries or, funds permitting, on their own desks (Table 4). These tables, indeed the whole of this article, are published in the hope that readers in Croatia (a country where spoken English is well taught and often excellent) will be encouraged to submit their research to English-language journals in the UK and USA.

Table 3. How non-English-speakers can improve their chances with an English-language journal

Hint	Explanation
Hide the penultimate draft	Do not rewrite for ever; the final version may well be worse than the third. Put the penultimate (e.g., third) draft in a drawer for a couple of days and then look at it with fresh eyes. You will need to revise it after refereeing anyway and that is the time for very minor adjustments of your own.
Do not write in your mother tongue	You can do this, later translating into English yourself or employing a translator, but at some point you will discover the advantages of using English first.
Show the paper to others	Colleagues in your own specialty if you wish but also someone in another specialty, particularly when submitting to a general journal.
Consult an English speaker	This can be done by sending the draft to a UK or US colleague or by making use of local language expertise. Some universities in Europe provide an "author's editor" service or you may have to pay for it.

Table 4. Suggestions for a medical writer's library[a]

Short title	Notes
ICMJE style (7)	These style guidelines are broadly accepted
CBE [now CSE] style (16)	More detailed on specific points of style
AMA style (17)	Similar to CBE
Cambridge style (18)	For editors but authors also
Journal instructions (13)	A compendium of 3500 journal guidelines
PubMed (19)	Reference searching, checking; journal abbreviations
Hart (20)	Aid for printers, copy editors – and authors
Strunk and White (21)	Similar to Hart
Fowler (22)	Guide to grammar and controversies in English
English dictionary (23,24)	Plenty of other choices, of course
Medical dictionary (25,26)	Again, plenty of choice
Journals now and then (27,28)	History of medical journals
Roget (29)	Thesaurus; alternative words
Ethical issues (30)	Medical journal controversies
Dates (31)	Medical history
Quotations (32,33)	General and specialist medical
Writing (34-36)	There are several other good, short books
Peer review (37,38)	Understand what referees do to your paper and why

[a]Most of these are on the author's personal bookshelf; the edition cited may not be the most recent.

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