

# Writing up your research

It's a skill that most of us will need at some point, and it doesn't have to be painful, say **Rebecca D Udani** and colleagues. They guide us through the process



**E**xcellent results, now all you have to do is write it up.” Have you ever heard this and broken out in a cold sweat at the thought of the task ahead? Well, don't panic. This article will provide the framework you need for “writing up” and act as an antidote to the feelings of impending doom.

A research report is the way that information is shared in the medical and scientific community. It is a summary of what you did, how you did it, what you found, and what it meant. Until the work is communicated or made public it's invisible and it's just not science until it can be evaluated and repeated by the rest of the scientific or medical community.

## Why bother?

As doctors and scientists we don't want to reinvent the wheel. If we are successful or the results are interesting we want to tell everybody, save lives, and reduce suffering. If there is a problem or the results are negative we also want everyone to know because we don't want others to repeat our mistakes, take the wrong road, or even build a square wheel. Where did we go wrong—was it in our hypothesis or our method? If our report is clear and accurate another group can repeat the study and find out.

Of course that's the bigger scientific and medical picture, but the research report may simply be part of your education, the end point of a research project. You may decide that you want to go on an elective in which you spend most of the time working on a research topic, or you may decide to intercalate a science degree. In either case the research report will play a large part in your final assessment.

The report allows the examiners to see if you understood the problem, how you analysed the data, your conclusions,

and of course your skill in presenting the final report. This article will focus on how to write such a report for a laboratory based project. But the principles are also relevant to reports for other types of projects.

Later, if you decide to carry out research as part of your clinical practice, these skills become essential for publishing a paper in a scientific journal. When you read papers as part of your everyday work, questions should pop into your mind. Is it a good study? Can I trust the results? How can I use this to improve my clinical practice?

Throughout our medical and intercalated degrees, we have worked on laboratory based as well as clinically oriented projects, and we wrote them up. We have presented our work internationally and this article sums up our experience. Our senior author Kevin Haylett has also completed a doctoral degree, which is the Mount Everest of writing up research.

## A typical structure

Although the style of the report will vary from journal to journal or between departments and disciplines, scientific and medical reports tend to have a standard internationally accepted structure that allows researchers to access information efficiently.

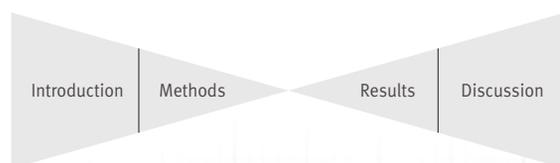
Figure 1 is a diagrammatic representation of the structure your scientific report should take. The introduction takes a broad look at the project, setting it against a background of previous research. The scope of the report then narrows through the methods and results sections to focus on the experiment in hand, and finally broadens out in the discussion to again relate the work to the bigger picture.

The key to the whole is the abstract, which opens the door into the report. Breathe easily; we will look at each individual component of the structure in turn.

## Abstract

The abstract is a summary of your report and should have the same structure. It should present the aims of the project, describe the experiments, and point out the major findings and conclusions. It should be self explanatory and give the reader an overall idea of the work, without the need to refer to the main report or references.

All this sounds simple, but fitting it all into a word



**Fig 1** Bow tie representation of a report's structure

limit of 200 to 300 words can be quite challenging. At times it's like a cryptic crossword as you try wording and rewording sentences so that they serve more than one purpose. Stay concise and don't let the words become nonsense and disappear with Alice into Wonderland. Paradoxically, although the abstract is the first part of the report it is usually easier to write last.

### Introduction

Provide a background to the work by giving a clear description of previous work in the field. To do this you must complete a literature review—searching for, finding, and reading relevant papers, which must be referenced in your report (box 1).

There are many different research methodologies that can be used to address a specific question. Ideally, the report should also explain why the particular study methodology was carried out and whether the study focus was on qualitative or quantitative data. Was a retrospective or prospective study more suitable? Was the study a meta-analysis, ie, an examination of existing research that brings the results together? Was the study more epidemiological, focusing on the distribution of patient data, rather than a simple comparison of two distinct groups?

Your introduction should explain your hypotheses and how you plan to test them, and it should describe your aims. It should clearly state what you expect to find and the reasoning that led you to the hypotheses that you have made. For a research report, the introduction should be longer than you would see in most scientific papers, but normally no longer than a quarter of the total length of the report.

### Methods

While conducting your research, stick to good practice and keep all the information and results in a notebook or lab book. This way the methods section will be the easiest to write. You simply describe how you went about your research. Give sufficient detail for the reader to be able to understand and repeat your experiments.

Include details of the materials used together with the manufacturer's name (box 2); this is especially important if your project was laboratory based and needed special chemicals and equipment.

If a particular procedure used is well known then there is no need to give a complete description; you can reference the paper in which it was first described and mention any modifications you have made. Finally, describe how you analysed your data, including the statistical methods and software package used.

### Use the passive voice

It is very difficult to use the active voice when documenting methods without using the first person, which would focus the readers' attention on the investigator rather than the work. It is now standard to write all scientific research papers using the third person passive voice. This is especially true when it comes to writing the methods section for research reports and papers. The modern scientific writing style has developed over many years and has come a long way. The scientists of the 17th century often described their work from a very personal viewpoint quite different from the writing style required by modern science (box 2).

### Results

This section should make your findings clear. There are many ways to do this and it has become easier with the introduction of spreadsheets. It is important not just to list a lot of numbers. Using a graph to represent your data will improve the reader's understanding.

There are wild and wonderful graphs you can draw, but be careful, do not throw caution to the wind. The computer can easily misrepre-

#### Box 1: Extract from an introduction we created

"Before 1990 no changes of nerve growth factor receptor expression secondary to neuronal injury were found (Kumar et al, 1988, Gauri et al, 1989). This has been blamed on poor sensitivity of the antibodies used. However, since then several studies have shown that injuries to neurones cause increased expression of nerve growth factor receptors (Cowburn et al, 1997, Warwick et al, 1999). However, these studies utilised a small number of samples. We aim to carry out a similar study using a larger number of samples."

#### Box 2: Extracts from the methods section of papers Excerpt from a 17th century paper on herbal medicine<sup>1</sup>

"It is of a clensing and cutting faculty without any manifest heat, moderately drying and binding; It openeth and clenseth the Liver, helpeth the Jaundice, and is very beneficial to the Bowels, healing all inward Wounds, Bruises, Hurts, and other distempers. The Decoction of the Herb made with Wine and drunk is good against the stinging and biting of Serpents, and helps them that have foul, troubled, or bloody waters, and makes them piss clear speedily; It also helpeth the Chollick, clenseth the Breast, and rids away the Cough."

#### Excerpt from a modern paper we created

"Immunocytochemistry was performed to determine the expression of specific proteins by neuronal cells. Primary antibodies (Baron, Preston) were raised against the specific proteins of interest. Once the primary antibody had been added, the cells were left to incubate at 4°C overnight."

sent your data. You need to be clear what type of graph is suitable for your information. For example, to represent the correlation between two variables, a line graph is preferred to a pie chart or a bar chart. See fig 2 for examples of good and bad graphs.

As with all sections, clarity and conciseness is vital. Don't present the same data more than once. Restrict yourself to the data that helps to address your hypotheses. This is important whether the data supports or disproves them. If you have carried out a statistical analysis, you should give the probability (P) value and state it is significant at the level you are testing. Depending on the analysis used, it may also be important to give the confidence intervals of the results, or other statistical parameters such as the odds ratios.

Where the research is less data driven and more qualitative it is equally important to explain the approach taken to the analysis. However the analysis is carried out, it is vital to follow the author's guidelines. It is not usually necessary in the results to show how the statistics were calculated. This can be left for the appendix if required.

Provide a caption for each figure making the general meaning clear without reference to the main text, but don't discuss the results. Let the readers decide for themselves what they think of the data. Your chance to say what you think comes next, in the discussion.

### Discussion

This section is where you interpret your data and discuss how your findings compare with those of previous researchers. From your literature review you should have the key references. Go over these and see if you can determine how your data fits with what they have found. Try to be critical, but do not discredit other people's work because all studies, even the best, can be improved.

You also need to account for the results, focusing on the mechanisms behind the observations (box 3). Importantly, there are no bad results. Science is not about right or wrong but about the continuing development of knowledge. Discuss whether or not your results support your original hypotheses. Negative findings are just as important to the development of future ideas as the positive ones.

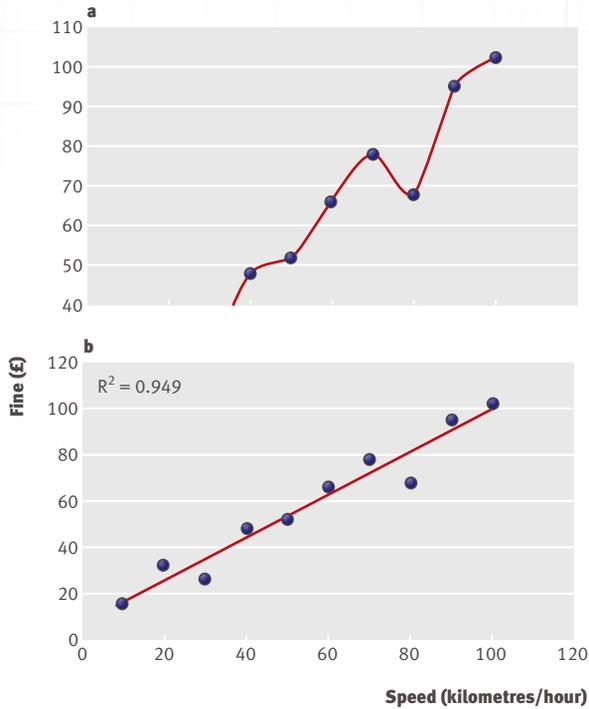
Discuss how errors may have been introduced into your study and what steps you took to minimise them. Suggest ways to improve future experiments. This shows that you are aware of the experimental limitations in your work and are seeking solutions to overcome them. Furthermore it shows that you appreciate the limitations of your results and the strength of your conclusions. You should also consider what further work would be desirable.

You must have a conclusion. It can be in the form of a short sentence or two at the end of the discussion or it can follow under its own separate heading. Either way it is important to have one as many readers will read the abstract and then quickly skip to the conclusion to see what it is you are actually getting at.

### Finishing off

As with most things, presentation is important. You should aim to keep your report as clear as possible. To make this easier you need to spend some time thinking about the style used (box 4).





**Fig 2** Examples of graphs. (a) This graph is poor as it does not contain a title; the x and y axes are unlabelled; and the line joining the points tells the reader nothing. Note the y axis starts at 40. This is misleading and it should really start at 0. (b) This graph was created with the same data as (a). The labels give meaning. Both axes start at zero. The regression line or line of best fit gives a better understanding of the trend between the two variables,  $r = 0.9321$ . The closer the correlation coefficient ( $r$  value) is to 1, the stronger the relation is between the two variables.

**Box 3: Extract from the discussion section of a paper we created**

“We found that protein expression increases with neuronal injury (52%,  $P < 0.05$ ). This finding is consistent with other studies (Dhanvant et al, 1994, Asha et al, 1996). This may be due to cytokine release from damaged neurones (Haylett et al, 1999).

**Box 4: Tips on good style**

- Clear headings for each section with clear font type and size.
- Start each new section on a new page
- Consider increasing your line spacing to 1.5 or double
- Consider justifying your text alignment
- Use bullet points to convey important information
- Have a contents page and a list of figures page
- A picture conveys a thousand words—use informative diagrams
- Number your pages
- Have a page explaining your abbreviations. Abbreviations should be written in full the first time you use them, with the abbreviations in parentheses. For example, “Congestive cardiac failure (CCF) is the final common pathway.”
- Use present tense to report well accepted facts
- Use past tense to describe specific results
- Use good quality paper (100 gms)
- Consider how you want your final report to be bound.

**Box 5: Useful websites**

- Owl online writing lab—<http://owl.english.purdue.edu/workshops/hypertext/reportW/>
- Experimental Biosciences—[www.ruf.rice.edu/~bioslabs/tools/report/reportform.html](http://www.ruf.rice.edu/~bioslabs/tools/report/reportform.html)
- StatPac. Elements of a research proposal and report—[www.statpac.com/research-papers/research-proposal.htm](http://www.statpac.com/research-papers/research-proposal.htm)

**Referencing**

The references are the foundation on which your report is built and should not be collected as an afterthought when you have finished, unless you want the report to topple over. Literature searches and reading of references should always be the starting point of your project. This section must be accurate and include all the sources of information you used.

There are many styles of referencing, although the two major types are the Harvard method and the Vancouver method. In the Vancouver format, references are numbered consecutively as they appear in the text and are identified in the bibliography by numerals in brackets. In the Harvard system, references are cited in the text by giving the author’s name and year of publication in brackets. In the bibliography, the references are listed in alphabetical order by the author.

Whatever style you decide to use, you must be consistent throughout. If you are writing your report for a medical school or intercalated degree assessment, you will be assessed on the accuracy of your references.

Technology comes to the rescue. Reference management software packages are a useful way of keeping track of your references. They integrate with your word processor and as you type you can insert the reference. Often these packages automatically create a list of references in the style you want. If a reference is added, deleted, or changed the reference order is magically updated. Reference managing software also allows you to download citations from the internet and save electronic copies of the abstracts. This can save you a lot of time and is well worth using. Don’t be fooled, however, you must still carefully check the final generated bibliography for any mistakes that may have occurred.

**Appendices**

All your raw data and statistical calculations can be placed in the appendices. This will allow the examiner or reader to be able to clarify anything they may not fully understand from your results. In addition, if your data collection involved questionnaires you can also keep a copy of the pro forma in the appendix. For laboratory based projects the ingredients of reagents used can be included in this section for completion.

**Acknowledgments**

You may wish to acknowledge people who have helped you. These can range from those who supported you with experimental techniques to those who read or offered advice on your final manuscript. Writing this article required the help of others—if you don’t believe us—read our acknowledgments.

**Take your time**

Writing a good research report takes time and effort. By following these guidelines you will be well on the way to success. Don’t forget to ask a friend or colleague to read through your report, as they will inevitably spot the minor mistakes and typos that you missed. You don’t have to stop here; for further information and advice see box 5 for useful websites, and it may be well worth taking a look at our references.

Remember, if you become overwhelmed by the task, stop and relax. Take a little time and think about the thoughts we have provided. You should then find yourself on your way again and before you know it you will have finished an excellent report.

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All references are on [student.bmj.com](http://student.bmj.com)