

Editorial: RMJ research series - writing up results

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A STUDENT'S EXPERIENCE:

In my first four years of medical school my work was mostly based around lectures and clinical activities. My interest in research started in my fifth year; at which time I had my first exposure to research through my dissertation, which I had to complete to gain my Bachelors in Medicine and Surgery. With little prior knowledge and experience, it was a great challenge to carry out such a project. I had particular difficulty when writing the results section: I found it challenging to choose what to include and what to omit from the manuscript as I had a lot of information after analysis of my data. Initially, I thought that I should include all my results (including all tables) in the manuscript. Thankfully, with the help of my supervisor, I learned that the results section must be organised in a logical and systematic way, and that superfluous data and results should be omitted to help draw the reader's attention to the most significant results. That information was key in helping me to improve the process of writing the results for my research project.

The "IMRAD" structure (Introduction, Methods, Results And Discussion) is widely used in writing original scientific literature [1], [2]. In this article, we continue with our Research Series which is designed to support interested researchers and readers in writing their papers or research essays by discussing the Results section of IMRAD [3].

TIP: Data should be restricted to tables and figures as much as possible [1]. Avoid simply repeating the data again in the text.

Statistics used

Before starting to present your results, you should ensure that you have used the correct statistical test to analyse the data (Table 1). This takes experience and should ideally be guided by a medical statistician. Research that is assessing diagnostic tests have their own statistical analyses (Table 2).

Table 1: A guide to test selection for epidemiological data [4]

Type	Specification	Test to use if data is	
		Normally distributed	Skewed / Ordinal
Comparing between	The odds of having a certain outcome with and without a measured exposure (case-control only)	Odds ratio (OR)	
	The risks of having a certain outcome with and without a measured exposure (cohort studies)	Risk ratio (RR)/Hazard ratio	
	The averages (means) of two independent groups	Independent t-test	Mann-Whitney test Wilcoxon rank sum
	The averages (means) of 3+ independent groups	One-way ANOVA	Kruskal-Wallis test
	The difference between the averages (means) of two paired samples	Paired t-test	Wilcoxon signed rank test
	>3 measurements on the same subject	Repeated measured ANOVA	Friedman test
Association between	2 continuous variables	Pearson's correlation coefficient	Spearman's correlation coefficient
	Continuous variables and any other type of variable	Simple linear regression	Transform the data
	Categorical variables and any other type of variable	Logistic regression	
	2 categorical variables		Chi-squared test

Table 2: Statistical tests for the appraisal of diagnostic tests

Test name	Meaning	Interpretation
Specificity	Represents the ability of a diagnostic test to correctly identify healthy people	The closer to 100% the better
Sensitivity	Represents the ability of a diagnostic test to correctly identify ill people	The closer to 100% the better
Positive Predictive Value (PPV)	The likelihood that a positive result is true	The closer to 100% the better
Negative Predictive value (NPV)	The likelihood that a negative result is true	The closer to 100% the better
Likelihood ratio (LR+)	The relative likeliness of the test being positive for someone with disease, compared with someone without.	The higher the better
Likelihood ratio (LR-)	The relative likeliness of the test being negative for someone with the disease, compared with someone without.	The closer to zero the better
ROC curve	Illustrates, for the benefit of comparison, the relationship between the true positive rate and the false positive rate.	The larger the area under the curve the better
Cohens Kappa	A measure of inter-rater agreement of a qualitative test (e.g. malaria identification on a thin film).	The closer to 1, the more reliable, > 0.7 is a reliable test

Other statistical tests

For particular study types, there are certain tests that readers will expect you to perform. These provide useful indices with which to compare multiple studies and are often reported on in meta-analyses. Some of these are listed below [5]:

- For appraisals of **investigations**, include sensitivity, specificity, PPV, NPV, and any information on prevalence is also important.
- For data on an **intervention**, include the number needed to treat/harm (NNT/NNH), risk ratio (RR), odds ratio (OR), and adjusted odds ratio (ARR).
- For data on **occurrence**, include incidence and prevalence.

Why worry about how you present your results?

Your results are the key output of your research project. It is imperative that they are presented accurately and clearly, while still remaining concise [6]. During any research project you are likely to gather large amounts of data of varying significance to your posed research question, and it is your job to synthesise this data and present it in a clear and objective fashion. If your results are presented in an unclear or disorganised manner, it is unlikely that the reader will be able to form a clear idea of the significance of the work that you have done.

TIPS:

While writing your results section, you must do the following [6]:

- Identify the key results which are relevant to your research question(s).

-Decide how the results are most effectively communicated

- Text
- Graphs
- Tables
- Figures

- Organise the data you are going to present in a systematic way that will make sense to the reader, for example:

- Chronologically
- Per the method of data collection
- From most to least important
- Focusing on different stated research objectives

- Summarize your different findings and direct the reader to relevant points in your figures, tables, and graphs.

What are the key sections to include in your results section?

The results section summarizes what the data shows by pointing out relationships and describing trends [1]. The presentation of the results needs to be systematic. The organization can differ based on your study design and the "story" you intend to tell with your data, but this is a basic layout of key subsections:

1. Participants and baseline data
2. Measures of key study variable occurrence (e.g.: incidence or prevalence)
3. Effect estimates and hypothesis testing

TIP: Break the Results section into subsections, with headings if needed [1].

Participant and baseline data

A good first step of analysis is describing characteristics of the study population, summarizing the data using count tables for categorical data, the mean and standard deviation for normally distributed numerical data, or with a median and interquartile ranges for skewed data sets [4].

Next, describe the occurrence of key study variables. For example, this could be an incidence or prevalence. Once you have described the occurrence of your key results, supported by any relevant statistical tests, it is necessary to calculate the effect size to determine the significance of your results and to answer your research question.

Other sections included depend on your specific study. For example, a study observing a change in a parameter over time can include a section within the results with a line graph depicting that change over time.

How to identify your key results?

How you identify and present your data has the potential to introduce reporting bias into your study. Results are interpretations and analyses of your raw data [7], you must therefore develop skills in identifying trends and ensuring that your data presentation does not confuse the reader.

Focus on identifying your most significant results (those included among your primary objectives), identifying your supporting results (secondary objectives), and noting results you think to be erroneous or outliers. The key results are not necessary those that are "significant" (i.e. $p < 0.05$). Results that are "non-significant" are often key results and may tell a story based on your objectives. Including data that refutes your hypothesis is just as important as including data that confirms it. You should also ensure you only present data that correlates with methodology detailed earlier in your article [6], [8].

Hypothesis testing and confidence levels

To describe "effect size" calculations, even before beginning your study you should have decided the confidence

level at which your study will be conducted (the most common is 95%). A confidence level of 95% will help you to calculate confidence intervals for all your data points, which describe the range of values that you are 95% sure the "real" value lies within, as sources of error inherent in your study design can lead to results that do not exactly correspond to the real population values you are studying.

When comparing values between two groups, you always start with a "null hypothesis" (H0) that there is no difference in a measured variable between the two groups. If your results are statistically significant, then you can "reject the null hypothesis", in other words, you are concluding that there is a difference between the two groups.

Alternatively, you can assess your hypotheses using p-values. A p-value of 0.05 corresponds to a 95% confidence level, and essentially states that "there is a 5% likelihood of the noted association being due to random chance". If you see a difference in a variable between two groups and the p-value is less than 0.05, then the chance that the observed difference being due to chance and not a "true" difference is less than 5%, and you can reject the null hypothesis. Many different statistical tests (Table 1) will provide you with a p-value but the way this p-value is calculated varies between different tests.

Some examples are listed below with a more comprehensive list available in table 1:

- Odds ratios are appropriate for case-control studies (choose study groups based on whether they have or do not have a condition, and then assess for different exposures).
- Risk ratios can be calculated for cohort studies (choose study groups based on exposures then follow for outcomes) or randomized trials.
- Chi-squared tests can show the association between categorical variables. For example, if the study population is classified into two groups based on a certain parameter, then chi-square statistics can show if there is a difference in the number of study subjects in each of the different groups.
- T-tests can show the association between the means of two continuous variables. If the study population is classified into two groups and each of the groups have a certain continuous variable measured numerically (such as electrolyte levels), then the averages of this measurement can be compared to look for a difference between the two populations.

TIP: remember to repeat and highlight in the text ONLY the most important numbers [1].

Tables and figures

If you are doing quantitative research, tables and figures will be the foundation for your manuscript and the "story" you are trying to tell. Editors, reviewers, and readers usually look at these first, along with titles and abstracts. They should therefore not require any "explanation" and should make sense standing alone [1]. Depending on the journal you submit to, you may need to place them either in-line with the text, or as an appendix at the end of the article (such as the RMJ).

You should consider how the data is best presented; should it be in a table, figure (graph or flowchart), or text form [6], [9], [10].

Use a table:

- To show many precise numerical values and other specific data in one space
- To compare and contrast data values or characteristics amongst related items/groups
- When the precise values are crucial to your argument and a graph would not convey the same level of precision
- When the presence of one or two very high or low numbers may detract from the message

Use a graph to:

- Show trends, patterns and relationships across and between data sets when the general pattern is more important than the exact data values
- Summarise research results in a visually appealing way

Use a flowchart to:

- Present a visual explanation of a sequence of events, procedures, geographic features or physical characteristics
- Use a Consort diagram to visually describe how participants were recruited. These depict the numbers at each step of inclusion and exclusion of patients (or studies, if a meta-analysis is being performed)

Use text:

- When there is no extensive or complicated data to present
- When putting data into a table would result in creating a table with two or fewer columns

When using tables and figures keep in mind that these are included for clarity, so they should be easy to read and understand. Each should be able to communicate its desired message without supporting text, and should be numbered with a descriptive heading and optional brief description. Number them consecutively in the sequence that they are first mentioned in the text, and insert them after the text which references them [6]. Refer to both graphs and flowcharts as "Figures" in the text. Use "n=" notation where appropriate to clarify the number of patients included in certain parts of tables or figures.

When making a table, care should be taken to present values with the same number of decimal places in all cells. Ensure consistent spacing in the boxes making up the table, and clearly label columns and rows [11]. Graphs should have clearly labelled axes, titles and numbering, and should avoid 3-dimensional layouts or axis scaling that may lead to a confusing interpretation.

What writing style is appropriate?

Use the first-person, past-tense and write with an active style [6]. Avoid unnecessary use of the passive tense ("The virus impairs hepatic function" is better than "there is an impairment of hepatic function associated with the virus") [7]. Focus on accuracy, clarity, and brevity, avoiding non-descript emotive language like "obviously," "really," "very," "somewhat," or "essentially." [6] [7]. Make sure to leave interpretation for the discussion section and do not repeat data presented in figures in text. Repetition does not add to the results section; rather it will bore the reader and will detract from more interesting text.

TIP: Do not include comments on the meaning of your results which should be found in the discussion section [8].

Appraising your work

TIP: Critical appraisal

One of the best ways to improve your write-up is to use an "EBM critical appraisal tool". These are freely available from many sources

1. Centre of Evidence Based Medicine (CEBM): Oxford University ([click here](#))
2. Critical Appraisal Skills Programme (CASP): Institute of Health Science, Oxford. ([click here](#))
3. The Joanna Briggs institute: University of Adelaide ([click here](#))
4. Faculty for medical and health sciences: University of Auckland ([click here](#))
5. Generic Appraisal Tool for Epidemiology (GATE): University of Auckland. ([click here](#))

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