CME Article

Effective Medical Writing

Pointers to getting your article published

Ng K H, Peh W C G

Preparing effective illustrations. Part 1: graphs

ABSTRACT

Illustrations (also known as figures) are visual representations of the results obtained from a scientific study. Graphs are a common type of illustration that are often used in scientific papers to present information clearly and effectively, as well as to demonstrate relationships between variables in the data. Graphs also serve to reveal trends or patterns in the data. This article provides some basic guidelines to assist authors in preparing effective graphs for their papers.

Keywords: figures, graphs, illustrations, medical writing, scientific paper

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INTRODUCTION

Illustrations (also known as figures) are visual representations of the results obtained from a scientific study. There are basically two types of illustrations that are used in scientific papers – graphs and pictorial images such as photographs/images/diagrams. Graphs are the most common type of illustration and will be discussed in this article. The other types of illustrations will be discussed in the next article.

On the whole, illustrations provide visual impact and are often the best way to communicate the main findings of a study. They are traditionally used to display trends and group results, but can also be used to communicate processes or to display detailed data in a simple yet effective manner.

The purpose of graphs is to present data that is too numerous or complicated to be described adequately in the text and/or to reveal trends or patterns in the data. Graphs (as well as tables) can be critical to achieving a better understanding of the results of a study. Readers who go beyond the abstract of a paper are likely to examine the graphs (and tables) next.

GENERAL GUIDELINES FOR PREPARING GRAPHS

Authors are often faced with the dilemma of whether to present data in a table or in a graph. One rule of thumb that can help us decide whether the data is best presented within the text or in a table or graph is: if the data shows pronounced trends, paints an interesting picture or reveals relations between variables in the data, then a graph should be used. If the data fails to show any exciting trend in the evidence, then a graph is clearly not the data presentation format of choice.

Organise the figures in such a manner that they tell a story. Be sure that all figures are cited within the text of the paper. Limit the number of illustrations to include only those that provide essential information that cannot adequately be described in the text. Number each figure in the order in which they are referred to in the text. Note that figures and tables should be numbered separately.

Typically, when submitting a paper for consideration for publication, figures are placed on separate pages following the reference section; the author should confirm this by checking the instructions to authors of the target journal. Generally, most journals require the figure legend and the figure to appear on the same page, with each figure labelled numerically in consecutive order and presented on a separate page.

Box 1. When to present data in graphs:

- Show trends and patterns in the data.
- Paint an interesting picture and make a visual impact.
- Reveal relations between variables in the data.

PREPARING GRAPHS

While there are sophisticated computer programmes available to assist with plotting graphs, it is still important for authors to pay attention to the principles of producing effective and informative graphs. The most basic

Biomedical Imaging and Interventional Journal, c/o Department of Biomedical Imaging, University of Malaya, Kuala Lumpur 50603, Malaysia

Ng KH, PhD, MIPEM, DABMP
Editor

Singapore Medical Journal, 2 College Road, Singapore 169850

Peh WCG, MD, FRCP, FRCR
Editor

Correspondence to:
Prof Ng Kwan Hoong
Tel: (60) 3 7949 2069
Fax: (60) 3 7949 4603
Email: dwlng@tm.net.my

requirement for a graph is clarity. Therefore, authors need to ensure that the size of the letters and symbols are chosen carefully so that the final version of the graph printed in the journal is clear and readable. The size consideration is important to withstand photographic reduction.

If two or more graphs are related, then it is common practice to combine them into a composite graph. Not only does this save space, but it also provides readers with a better picture that allows viewing of the related parts in one location. Do not extend the abscissa (x-axis) or the ordinate (y-axis) beyond the data that is presented in a graph. For example, if the data points range from 0 to 75, the maximum index number should be 80, and the data points should be 0, 20, 40, 60 and 80. Avoid the tendency to extend the graph to 100. Although this may sound like a nice round number, it will result in empty white space in the upper part of the graph, and the important data will only occupy the lower part instead of the whole graph.

Use standard symbols for graphs. Some common ones include open and closed circles, triangles and squares (○, △, □, ●, ▲, ■). If the graph has one curve, use open circles for the reference points; if it has two, use open triangles for the second curve, etc.

Graphs are usually plotted in black on a white background, using the same font type and size as the text. It is extremely expensive to publish in colour, so this should only be used when it highlights unique information or when it cannot be clearly presented in black and white.

CHOOSING THE CORRECT GRAPH TYPE

Choose the correct graph type based on the kind of data to be presented: (1) if independent and dependent variables are numeric, then use line diagrams or scattergrams; (2) if only the dependent variable is numeric, then use bar graphs; (3) for proportions, use bar graphs or pie charts. Some of the common graph types are shown in Appendix 1. Other types of graphs include: frequency polygon, age pyramid, survival curve, and receiver operator characteristic (ROC) curve.

PROVIDING LEGENDS

Provide a clear, descriptive legend for each graph. Like the title of the paper itself, each legend should concisely convey as much information as possible about what the graph tells the reader. However, a legend should not provide a summary or interpretation of the results or experimental details. A legend should be placed at the bottom of each graph. Examples of graph legends that appeared in recent issues of the Singapore Medical Journal are:

1. Bar chart shows the combined usage data of key antibiotic classes in local public hospitals according to defined daily dose per 1,000 patient-days.
2. Graph shows the incidence of cleft deformities in relation to the number of live births during the period 1993–2002.

Do not simply restate the axis labels with a "versus" written in between, for example, "Graph shows temperature vs. time". Instead, label each axis with the relevant unit of measurement (where applicable), and clearly identify the data by labelling each line in a graph. Figures should be of high image quality. Check the journal's instructions to authors on which image file format the journal requires.

Box 2. Common errors:

- Information in the text is duplicated in graphs, or information in graphs is duplicated in tables.
- The graph does not have proper legends.
- The wrong type of graph is chosen to represent the data.
- The graph is not plotted to scale. Data is not labelled, is inconsistent, interrupted, or exaggerated to produce the desired effect.
- The source of previously-published data is not credited.
- The misuse of pseudo three-dimensional graphs.

SUMMARY

Graphs are helpful tools for improving the readability of a scientific paper as they present data in a clear and effective manner. They make a visual impact and can be used to reveal trends or patterns in the data. Authors should decide which types are most suitable for publication before designing clear and effective graphs following the guidelines outlined in this article.

Box 3. Take home points:

1. Prepare the results and data of the study before drafting the graphs.
2. The flow of the graphs should tell a logical story.
3. Choose the appropriate graph type to match the study data.
4. Design, provide legends and label the graphs carefully so that they are clear and easy to understand.

Appendix 1. Common graph types.

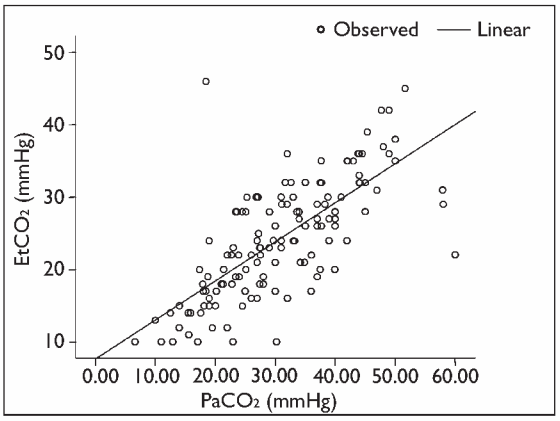
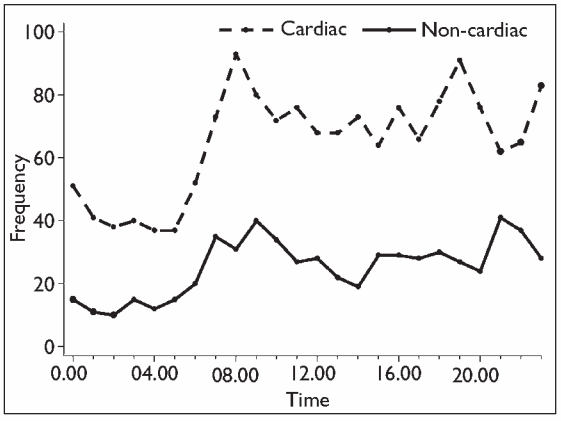
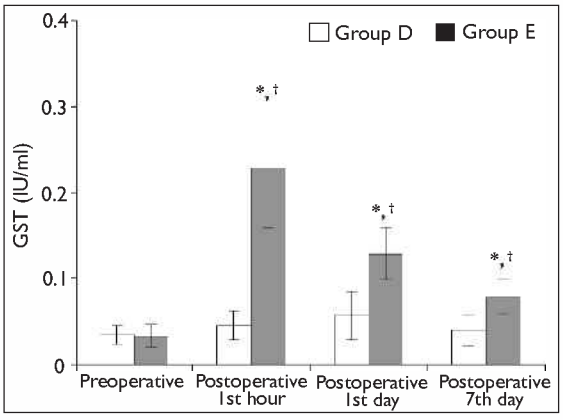
Type	Purpose	Example
Scattergram	It is used to present measurements on two or more variables that are related; the values of the variables on the y-axis are dependent on the values of the variable plotted along the x-axis.	
Line graph	It is similar in some ways to the scattergram, with the condition that the values of the x variable have their own sequence. Those values represent a continuous variable, such as time, temperature or pressure. It may display several dependent variables on the same graph.	
Bar graph (also known as bar chart)	It may either be horizontal or vertical (column graph). An important point about bar graphs is the length of the bars: the greater the length, the greater the value. It is used for discrete, grouped data of ordinal or nominal scale.	

Fig. 1 Scattergram shows the relationship between the end-tidal and arterial carbon dioxide.
n = 133; r = 0.73; p < 0.001

Fig. 2 Graph shows the hourly frequencies of out-of-hospital cardiac arrest patients in a 24-hour cycle.

Fig. 3 Bar chart shows the glutathione-S-transferase (GST) levels (mean ± SD).
* p < 0.05 when compared to the Group E level
† p < 0.05 when compared to the preoperative level

Histogram

It is a specialised type of bar graph that resembles a column graph but there are no gaps between the columns. It is used to represent data from the measurement of a continuous variable. Individual data points are grouped together in classes to show the frequency of data in each class. The frequency is measured by the area of the column.

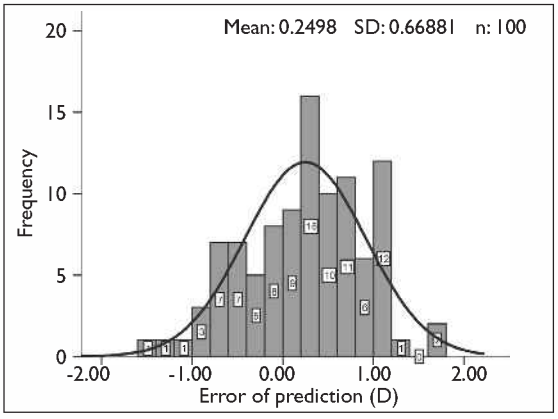


Fig. 4 Histogram shows the postoperative range of errors of prediction.

Pie chart

It shows classes or groups of data in proportion to the whole data set. The entire pie represents all the data, while each slice or segment represents a different class or group within the whole. Each slice should show significant variations. The number of categories should be small (between three and ten).

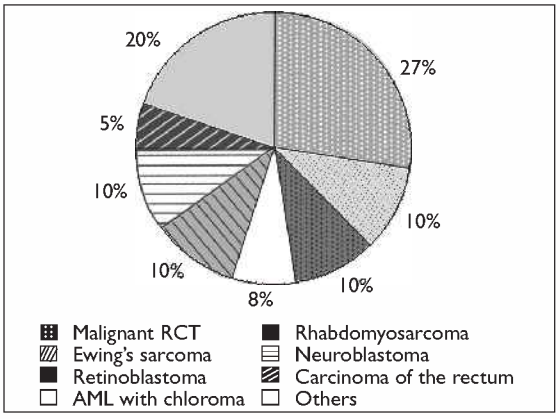


Fig. 5 Pie chart shows the distribution of the different types of tumours.

Box plot (also known as box-and-whisker plot)

It may be either horizontal or vertical. It is used to display a statistical summary of one or more variables: minimum, lower quartile, median, upper quartile and maximum. It may also indicate which data might be considered as outliers. The spacing between the different parts of the box indicate the degree of dispersion (spread) and skewness in the data. This helps in visualising the type of data distribution, whether symmetrical or skewed.

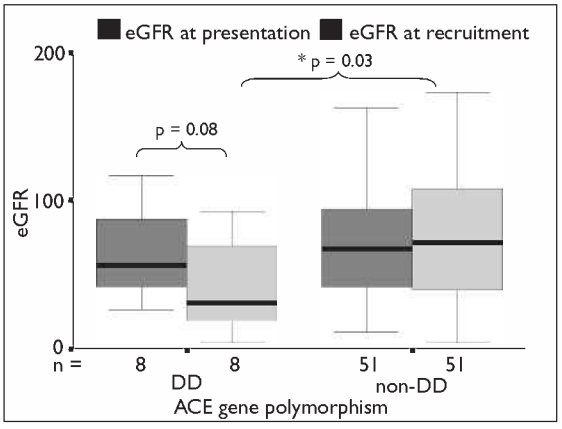


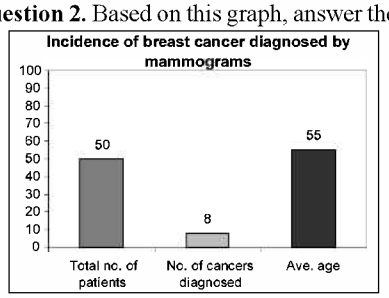
Fig. 6 Boxplot shows the angiotensin-converting enzyme gene polymorphism and disease progression in the DD and non-DD patients.
eGFR: estimated glomerular filtration rate; DD: deletion/deletion genotype
* p-value is statistically significant

Examples are taken from recent articles published in this journal.

SINGAPORE MEDICAL COUNCIL CATEGORY 3B CME PROGRAMME
Multiple Choice Questions (Code SMJ 200903B)

	True	False
Question 1. The purpose of graphs is:		
(a) To reveal trends or patterns in the data.	☐	☐
(b) To reveal relations between variables in the data.	☐	☐
(c) To present large amounts of repetitive data.	☐	☐
(d) To paint an interesting picture.	☐	☐

Question 2. Based on this graph, answer the following questions:



(a) The graph is most appropriate for inclusion in the text.	☐	☐
(b) The graph could be simply replaced by one sentence in the text: "Eight out of 50 patients with a mean age of 55 years were diagnosed with breast cancer".	☐	☐
(c) The graph should be replaced by a table.	☐	☐
(d) A pie chart is more appropriate for presenting this information than a bar graph.	☐	☐

Question 3. When preparing graphs:

(a) All figures must be referenced in the text.	☐	☐
(b) Do not include experimental details in the legend.	☐	☐
(c) Ensure that the size of the font and symbols are appropriate so that they can be read when the graphs are printed.	☐	☐
(d) Always prepare them in full colour.	☐	☐

Question 4. Regarding graph legends:

(a) They are always placed below the graphs.	☐	☐
(b) An example of a good legend is: "Graph shows temperature vs. time".	☐	☐
(c) They should be clear and concise.	☐	☐
(d) They should provide an interpretation of the results.	☐	☐

Question 5. The following statements regarding types of graphs are true:

(a) Box plots show a distribution of data.	☐	☐
(b) Bar graphs are used to display continuous data.	☐	☐
(c) Pie charts show classes of data in proportion to the whole data set.	☐	☐
(d) Line graphs allow the display of only one dependent variable.	☐	☐

Doctor's particulars:

Name in full: _____

MCR number: _____ Specialty: _____

Email address: _____

SUBMISSION INSTRUCTIONS:
(1) Log on at the SMJ website: http://www.sma.org.sg/cme/smj and select the appropriate set of questions. (2) Select your answers and provide your name, email address and MCR number. Click on "Submit answers" to submit.

RESULTS:
(1) Answers will be published in the SMJ May 2009 issue. (2) The MCR numbers of successful candidates will be posted online at www.sma.org.sg/cme/smj by 20 May 2009. (3) All online submissions will receive an automatic email acknowledgment. (4) Passing mark is 60%. No mark will be deducted for incorrect answers. (5) The SMJ editorial office will submit the list of successful candidates to the Singapore Medical Council.

Deadline for submission: (March 2009 SMJ 3B CME programme): 12 noon, 15 May 2009.