

Principles of visual design in cognitive aid development

Daniel Moi MBBS BSc(Med) MPH MMed CertDes

Provisional Fellow, Department of Anaesthesia, Pain, and Perioperative Medicine, Royal North Shore Hospital, Australia

Jessie Maulder MBBS (Hons), MPH, FANZCA

Consultant Anaesthetist, Department of Anaesthesia and Perioperative Medicine, Royal Hobart Hospital, Australia

Daniel Zeloof MBBS BSc (Hons) FRCA FANZCA PGDipCU

Consultant Anaesthetist, Department of Anaesthesia, Pain, and Perioperative Medicine, Royal North Shore Hospital, Australia

Dushyant Iyer BMed MD MMed (CritCare)

Anaesthetic Registrar, Department of Anaesthesia, Pain, and Perioperative Medicine, Royal North Shore Hospital, Australia

Edited by Dr Jana Vitesnikova

INTRODUCTION

Design is interwoven into our lives, and we are all experts – to paraphrase Tim Brown, industrial designer and CEO of the global design consultancy firm IDEO¹:

“Design is everywhere, inevitably everyone is a designer.”

And we agree! – in the sense that everyone is able to say “That looks good” or “I don’t like the look of that!” instinctually and quickly. Understanding this interplay between the designer and the user is critical in producing cognitive aids that are effective.

There is an ongoing groundswell in the use of cognitive aids to assist clinicians in the time-critical and high-stakes environment of acute care medicine. This article provides a practical overview on the principles of visual design and its application in the development of these cognitive aids.

Well-designed cognitive aids are important contributors to safe and appropriate patient management in complex clinical situations. However, designs that have been disadvantaged by time and production constraints or other factors may be less clinically helpful.

We will share lessons that we have learnt within our non-profit organisation, Anaesthesia Cognitive Aids and Research (ASCAR) – and we hope these are helpful to anyone involved, or interested, in the development of cognitive aids.

DESIGN

Purpose

Design is about purpose.

“Design is a plan for arranging elements in such a way as best to accomplish a particular purpose.”

– Charles Eames, American designer (of Eames chair fame), architect, and filmmaker²

And, as such, the first question that must be asked and answered when designing something is “Why?”. Why are we doing this? To create a visual summary for a lengthy clinical practice guideline? To improve upon an existing cognitive aid? To simplify a crisis management process? To incorporate recent updates in clinical management?

Content first

The next step in our process of designing a cognitive aid is the content. When the content has been established, the necessary layout and visual design often flows naturally. Different designs will lend themselves better to different situations, and it is much easier to experiment with moving things around when the content is “locked in”. That said, the content can be – and should be – edited and improved with new evidence and user feedback.

This principle can be related back to the purpose of design. With the content established, the design process is then about arranging elements in such a way to accomplish a particular purpose. This approach ensures that the cognitive aid solves the problem that prompted its creation. A beautiful raincoat that doesn't keep out the rain would not be considered great design, just as a perfectly waterproof raincoat that doesn't allow mobility would be considered poor design.

Respect

It is very important to be respectful when reviewing or updating existing designs. There must be an appreciation of the time and effort invested in any creative endeavour. We feel very strongly in favour of viewing all previous designs as a success – design is an iterative process, and getting a design “out there” for user feedback and subsequent improvement should be appreciated.

We echo this quote from Michael Bierut, a renowned graphic designer and creator of the Verizon, Mastercard, Billboard logos (among many other achievements):

“For all that, though, these are all deliberate decisions. So someone clearly designed it, which is a cause for applause.”

– Michael Bierut, graphic designer, design critic, educator³

User feedback

The user experience is primarily shaped by both the form (aesthetics) and function (purpose) of the product – but there are multiple secondary modulators, such as human factors and the specific context of its use. Therefore, the interplay of form and function for any product can only be determined by releasing it to the intended audience – for use “in the real world”. Feedback should be actively requested, and barriers to its delivery should be minimised (for example, a form on your website/a contact email). User research and product feedback are very important tools in design – “just making things pretty” will not create great cognitive aids.

Iteration and versioning

The advent of digital documents, and the movement away from physical print material has made the iterative process much easier. At ASCAR, we version stamp our designs, initially with a “v1.0 2023” after the launch product is achieved. Subsequent minor revisions, such as typos or minor text changes will have a “version bump” to v1.1 and so on. Major revisions, such as significant content or layout changes – usually from user feedback! – will be versioned to v2.0 and so on. In addition, if these assets are stored in the cloud, then a generic URL (such as example.com/anaphylaxis-cognitive-aid) should be distributed to users. The document can continue to be iterated upon, updated, and re-versioned – but the user always gets the most recent version upon accessing that URL.

VISUALS

Fundamentals

Visual design and the principles of effective graphic design and communication are expansive topics that can be daunting to tackle. One useful approach is to start with a set of design fundamentals, which include balance, alignment, hierarchy, contrast, rhythm, proximity, colour, and space.^{4,5} There is infinite value in investing time and effort into understanding and implementing these concepts into your designs. It is helpful to note that there are a vast amount of online (both free and paid) resources available. Curated collections of these resources can provide a useful list of higher quality options.⁶

Layout

Some principles behind effective document layout are worth a particular mention:

- Don't overcrowd the design – use white space to create balance
- Use position and grouping to create visual hierarchy⁷
- Ensure consistent vertical and horizontal alignment – use the ruler and spacing tools of your chosen design software program

Left-alignment should be used for both lists and paragraphs – the human eye scans down the left-hand side when appraising a block of left-to-right text (a concept known as the F-pattern).^{8,9}

- | | |
|---|--|
| <ul style="list-style-type: none"> • Left-aligned points • Are easy to read • With short processing time • Less eye scanning required | <ul style="list-style-type: none"> • Centre-aligned points • Are less easy to read • Require longer processing time • More eye scanning required |
|---|--|

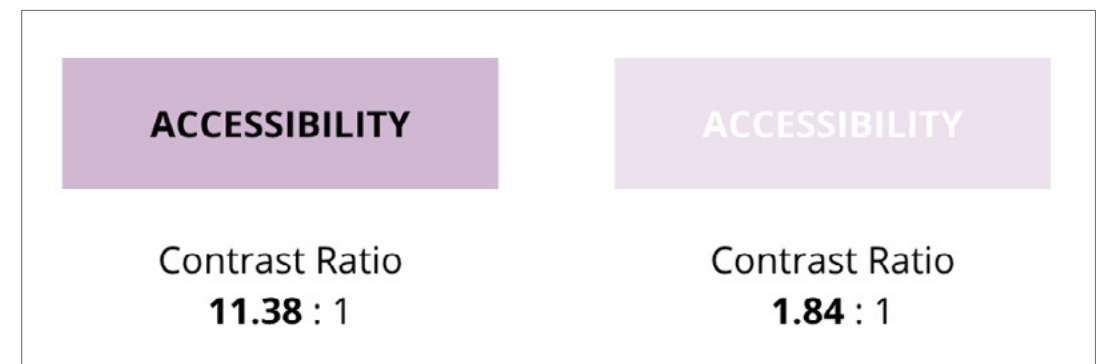
Colour

Colour theory is a huge topic, replete with confusing terminology such as hue, chroma, saturation, value, tone, shade, tint – in addition to colour scheme concepts such as monochromatic, analogous, and complementary colours.¹⁰ Here are our tips on effective colour management:

- Establish a specific colour palette of approximately 6 colours
- Technology can assist with colour decisions (for example, [Adobe Color Wheel](#))¹¹
- Consider the emotion of colour – do you want to convey a bright or formal mood?
- Conventional colours can assist with cognitive association
 - Red = neuromuscular blocking agents
 - Purple = vasopressors/inotropes

Accessibility

Particular attention should be given to colour accessibility – ensuring that the contrast of colours between the text and background is readable. Use online tools, such as [WebAIM](#), to establish objective assessment of contrast – all components should have a contrast ratio of at least 4.5:1.¹²



Typography

Typography is another complex area in visual design. A broad understanding of the terminology is important¹³:



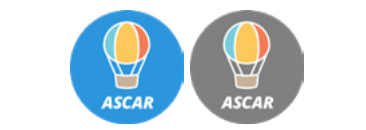
- Typeface – a family of fonts
- Font – a specific variation in weight and size of a typeface
- Typography – how text and letters are arranged within a design

While endless hours can be spent deliberating over typeface choices, here are some helpful principles for effective typography:

- Use online tools to assist with your choices (for example, [Typewolf](#))¹⁴
- Sans serif typefaces (e.g. Arial / Helvetica) are cleaner and more legible than serif typefaces (e.g. Times New Roman)
- A single typeface for a document is more effective than multiple typefaces (for example, one for headings, one for subheadings, one for body text)
- Prefer simple fonts that are legible over novelty fonts that are playful

Icons

Icons can be a very effective method of assisting visual communication in a cognitive aid. They also introduce visual interest and can help with creating intuitive sections within a layout. While we were fortunate at ASCAR to have the resources to create our own library of icons, this is definitely not a necessity – there are many free icon libraries available online. However, this did confer a unique and unified visual identity across our cognitive aids, and we were able to create icons for more specialised medical equipment. Icons, with simple lines and considered colours, can also create positive emotions and evoke a sense of joy – effects that influence human performance significantly.

	<p>Some ASCAR airway icons</p> <ul style="list-style-type: none"> ▪ ETT, Video Laryngoscope, LMA ▪ We chose blue for our “airway colour”
	<p>Some ASCAR custom icons</p> <ul style="list-style-type: none"> ▪ Transport (ventilator and drugs) ▪ Epidural catheter ▪ EZ-IO
	<p>ASCAR logo</p> <ul style="list-style-type: none"> ▪ A tri-coloured symmetric balloon to convey design, creativity, and joy

Style guide

One of the most effective ways to establish consistent design with a cognitive aid – and between multiple cognitive aids – is to create a visual style guide.¹⁵ This document becomes a reference repository of all the visual design decisions that have been made, such as the colour palette, typography, and so on. Style guides are often incorporated with broader organisational resources such as logos and mission statements.

TECHNICAL

Spelling and grammar

This is a non-negotiable. All professional documents should have correct spelling and grammar. Use a spell checker – and address the red wiggly lines! Another tip: change your computer’s language settings to UK/Australia (this will prevent incorrect spell checks using US spelling).

Units of measurement

It is important to ensure that the units of measurement are written correctly – with reference to the International Bureau of Weights and Measures (BIPM)¹⁶ and the National Institute of Standards and Technology (NIST) Reference on Constants, Units, and Uncertainty.¹⁷ There are also excellent guides available from the Australian government¹⁸ and the Cochrane community.¹⁹ Some important examples:

- Put one space between the numerical value and the unit symbol
 - Correct: Paracetamol 15 mg/kg (max 1 g)
 - Incorrect: Paracetamol 15mg/kg (max 1g)
- Degrees of temperature require a preceding space
 - Correct: Cool patient to 38 °C
 - Incorrect: Cool patient to 38°C
- Degrees of arc do not require a preceding space
 - Correct: Turn the bevel 90°
 - Incorrect: Turn the bevel 90 °
- Use correct case
 - Correct: Fluid bolus 20 mL/kg
 - Incorrect: Fluid bolus 20 ml/kg
- No plural “s” for units
 - Correct: Adrenaline 1 mg
 - Incorrect: Adrenaline 1 mgs

Drug names

Pharmaceutical drugs should be referenced using their generic names – use the Recommended International Nonproprietary Name (RINN).²⁰ While it is often recommended to use lowercase for generic names, and Capital case for brand names,²¹ we have often used Capital case for generic names to improve visual clarity. As always, choose one convention and keep it consistent across all your documents. Example:

- Correct: Draw up midazolam and fentanyl
- Our preference: Draw up Midazolam and Fentanyl
- Incorrect: Draw up Midazolam and fentanyl

Capitalisation and emphasis

It is important to adopt consistent usage of capitalisation.²²

- Title Case: Management of Intraoperative Hypotension
- Sentence Case: Management of intraoperative hypotension
- Initial Case: Management Of Intraoperative Hypotension
- All Caps: MANAGEMENT OF INTRAOPERATIVE HYPOTENSION

We feel that Title Case is a very sensible choice for headings in cognitive aids. We also advise strongly against using All Caps for any headings, because it reduces legibility and prolongs reading time.²³ Emphasis can be more effectively achieved with the use of underline or **bold** or *italic* – but not in **combination**.

Legal

A disclaimer is a statement that denies legal responsibility. Most medical organisations will have a legal disclaimer on their website to reduce the legal risk associated with producing clinical resources. While there are many free templates available on the internet, we would recommend seeking formal legal advice to ensure that this is managed appropriately.

A decision also needs to be made with regards to copyright and intellectual property rights to the cognitive aids being produced. All the cognitive aids and resources we make at ASCAR are released under a Creative Commons licence, which gives other people the right to share, use, and build upon those aids.²⁴ The specific licence we have chosen is termed Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0),²⁵ but it is important to decide upon a licence that is best suited to your individual circumstances.

Language

Language must be used effectively when creating any visual designs. This is obviously a huge topic, and is excellently covered by experts – such as *The Elements of Style*.²⁶ Some practical points that we have learnt:

- Aim for brevity
- Omit the “articles of speech” (the / a / an)
- With: Determine the cause
- Without: Determine cause
- Minimise tautology, for example, prefer “administer” over “rapidly administer”
- Prefer dot points over paragraphs or blocks of text
- Use a consistent and appropriate tone of voice
- Advisory statements (“consider Magnesium”) confer more legal protection than prescriptive statements (“use Magnesium”)

A good example of how language can be confusing – a website about malignant hyperthermia contained multiple different instructions for temperature management:

- Cool the patient to 38 °C
- Cool patient to 38 °C
- Stop cooling measures when temperature falls to 38 °C
- Cool the patient if core temperature is > 39 °C
- Stop cooling when the temperature has decreased to < 38 °C

We would advocate “Cool patient to 38 °C” for these (opinionated) reasons:

- It is the simplest sentence
- It omits the article “the” – brevity without losing meaning
- “Cool” – focuses on the therapy, whereas “stop cooling” focuses on the cessation of therapy
- The word “temperature” is unnecessary
- The “greater than” (>) and “less than” (<) symbols add cognitive load

The careful and deliberate choice of language will elevate the performance of cognitive aids – and language that is consistent and simple is equally important.

ASCAR

History

ASCAR (Anaesthesia Cognitive Aids and Research) was formed in 2019 at Royal North Shore Hospital in Sydney, Australia, by Jessie Maulder and Daniel Zeloof when they were anaesthesia registrars, and later joined by Daniel Moi and Dushyant Iyer, with a goal of developing and refining high-quality cognitive aids to assist anaesthetists in crisis management. During this process, we have had the privilege of working together with many clinicians across many specialties, including anaesthesia, intensive care, emergency, surgery, and retrieval medicine. There has been close collaborative work involved in developing these cognitive aids, as well as in expert review for clinical governance. We are pleased that our cognitive aids have evolved to be used in the wider critical care context, including medical education and clinical simulation.

We have been very fortunate to have had tremendous support and advocacy from our magnificent department and colleagues at Royal North Shore Hospital. In addition to the clinical environment of a major tertiary referral hospital, our department has always fostered a strong focus on human factors and non-technical skills in crisis management, as well as an ongoing close affiliation with the Sydney Clinical Skills and Simulation Centre.²⁷

As a result of this ongoing team effort, we have been able to release cognitive aid booklets for neuroanaesthesia, obstetric anaesthesia, paediatric anaesthesia, and trauma – as well as collections of aids on airway management, cardiothoracic anaesthesia, general procedures, COVID-19, and human factors. All our cognitive aids are presently available for free in our mobile iOS and Android applications, and we maintain an active social media presence on Twitter and Instagram to maximise our contribution to the wider medical community.

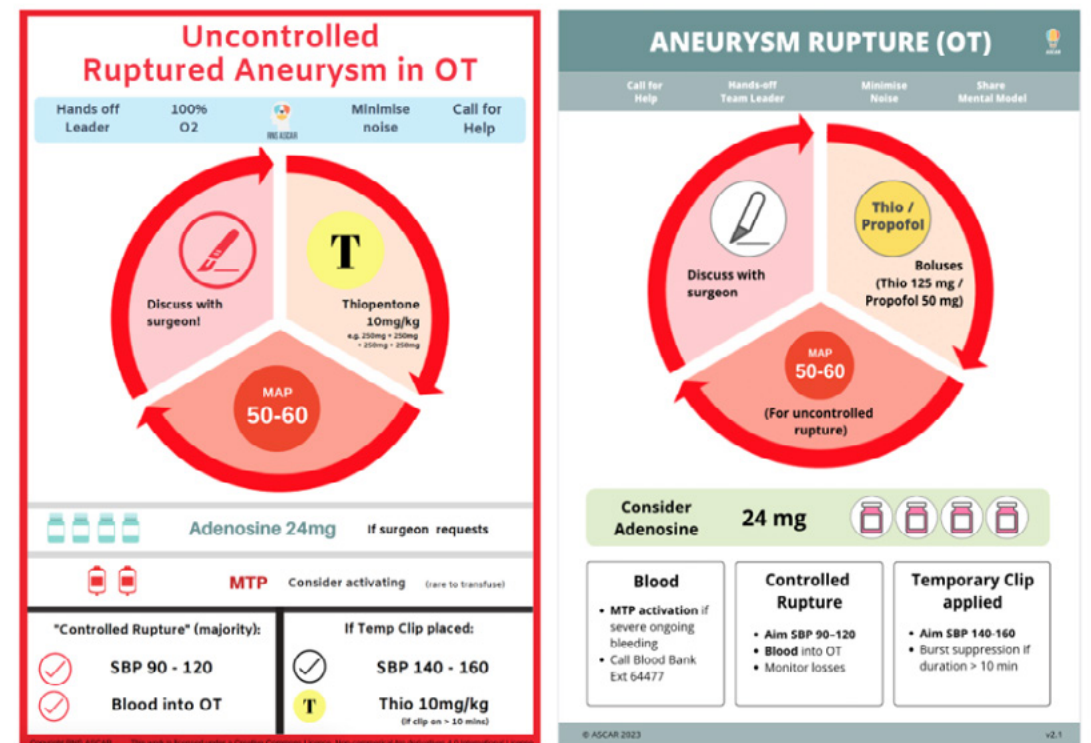
Toolbox ideas

A common question that we get asked is what tools and software we use in our development pipeline. The tools available to the designer change constantly, and we appreciate the broad variation in technical backgrounds of people interested in developing cognitive aids. We champion the use of tools that are intuitive, easy-to-use, and that facilitate collaboration. Our toolbox adapts to our needs, and we encourage this flexibility – from paid subscription software from established players (for example, Adobe Illustrator, InDesign, Photoshop), to their newer and free/freemium counterparts (for example, Canva, Figma, Google Docs, Draw.io).

Example of cognitive aid development

We thought it would be interesting to close with a closer look at the iterative process of one of our own cognitive aids. Intracranial aneurysm rupture is a neurosurgical emergency, and we feel the development of this cognitive aid provides a useful practical review of the areas we have addressed in this article.

- Design. The purpose of this aid was to provide assistance in the crisis management of a neurosurgical emergency.
- Visuals. The overall simple layout has been retained, with the 3-sector centrepiece, a highlight panel (Adenosine), and secondary panels (Blood, Controlled rupture, and Temporary Clip). Some changes include a revised header and subheader, implementation of our new icons, and some adjustments in the layout, balance, palette, and rhythm of the cognitive aid.
- Technical. The language has been modified to promote the active voice, and the spacing of the units of measurement has been corrected.
- Overall. While the content has remained broadly the same (the content being the foundation of all visual documents), we feel that the visual impact and user experience has been improved due to an (ongoing) process of iteration and user feedback.



Contact details

We are always available at hello@ascargroup.com and on [Twitter](#) and [Instagram \(@ascargroup\)](#) 🙌 – drop us a line!

ACKNOWLEDGEMENTS

We are deeply appreciative of the support, training, and mentorship that we have received at the Royal North Shore Hospital Department of Anaesthesia and all the other centres that we have had the privilege of working at. We look forward to many more ongoing iterative collaborations and encouraging similar endeavours – as we help each other in improving patient safety and outcomes in anaesthesia and crisis management in the critical care environment.

REFERENCES

1. Lavender P. Ideo CEO Tim Brown: 'Everyone Is A Designer' [Internet]. HuffPost; 2014 [cited 2023 June 5]. Available from: https://www.huffpost.com/entry/tim-brown-davos_n_4635681.
2. Kim M. The Meaning of Design: What Design Is and Why It's Important [Internet]. Shakuro; 2020 [cited 2023 May 28]. Available from: <https://shakuro.com/blog/the-meaning-of-design-what-design-is-and-why-its-important>.
3. Dunlap D. Reviews Trickle In for New Taxi Logo [Internet]. The New York Times; 2007 [cited 2023 June 27]. Available from: <https://archive.nytimes.com/cityroom.blogs.nytimes.com/2007/10/15/reviews-trickle-in-for-new-taxi-logo/>.
4. Hayward-Cole A. 7 basic principles of graphic design [Internet]. London College of Contemporary Arts; 2019 [cited 2023 June 27]. Available from: <https://www.lcca.org.uk/blog/careers/7-basic-principles-of-graphic-design/>.
5. Cheyenne M. Design Fundamentals: Elements & Principles [Internet]. Berkeley Library, University of California; 2021 [cited 2023 June 27]. Available from: <https://guides.lib.berkeley.edu/design>.
6. Fleck R. 10 Excellent Free Online Graphic Design Courses [Internet]. Dribbble; 2022 [cited 2023 June 27]. Available from: <https://dribbble.com/resources/free-graphic-design-courses-online>.
7. Murchie K, Diomedede D. Fundamentals of graphic design—essential tools for effective visual science communication [Internet]. Facets; 2020 [cited 2023 June 27]. Available from: <https://www.facetsjournal.com/doi/10.1139/facets-2018-0049>.
8. Babich N. F-Shaped Pattern for Reading Content [Internet]. UX Planet; 2017 [cited 2023 June 27]. Available from: <https://uxplanet.org/f-shaped-pattern-for-reading-content-80af79cd3394>.
9. Doreng-Stearns N. Using F and Z patterns to create visual hierarchy in landing page designs [Internet]. 99designs; 2016 [cited 2023 June 27]. Available from: <https://99designs.com/blog/tips/visual-hierarchy-landing-page-designs/>.
10. Chapman C. Color Theory for Designers, Part 3: How To Create Your Own Color Schemes [Internet]. Smashing Magazine; 2021 [cited 2023 June 23]. Available from: <https://www.smashingmagazine.com/2010/02/color-theory-for-designer-part-3-creating-your-own-color-palettes/>.
11. Adobe. Adobe Color [Internet]. Adobe; 2023 [cited 2023 June 27]. Available from: <https://color.adobe.com/>.
12. WebAIM. Contrast Checker [Internet]. WebAIM; 2023 [cited 2023 June 27]. Available from: <https://webaim.org/resources/contrastchecker/>.
13. Kramer L. Typeface vs. font: what's the difference? Does it matter? [Internet]. 99designs; 2021 [cited 2023 June 27]. Available from: <https://99designs.com/blog/tips/typeface-vs-font/>.
14. Typewolf. Guides & Resources [Internet]. Typewolf; 2023 [cited 2023 June 27]. Available from: <https://www.typewolf.com/guides>.
15. Jordan C. How to create a visual brand style guide [Internet]. Canva; 2023 [Available from: <https://www.canva.com/learn/your-brand-needs-a-visual-style-guide/>].
16. Bureau International des Poids et Mesures. SI Brochure: The International System of Units (SI) [Internet]. Bureau International des Poids et Mesures; 2022 [cited 2023 May 28]. Available from: <https://www.bipm.org/en/publications/si-brochure>.
17. National Institute of Standards and Technology. International System of Units (SI) [Internet]. National Institute of Standards and Technology; 2019 [cited 2023 June 27]. Available from: <https://physics.nist.gov/cuu/Units/index.html>.
18. Australian Government. Measurement and units [Internet]. Australian Government; 2023 [cited 2023 June 27]. Available from: <https://www.stylemanual.gov.au/grammar-punctuation-and-conventions/numbers-and-measurements/measurement-and-units>.
19. The Cochrane Collaboration. Units and systems of measurement [Internet]. The Cochrane Collaboration; 2019 [cited 2023 June 27]. Available from: <https://community.cochrane.org/style-manual/numbers-statistics-and-units/units-and-systems-measurement>.
20. World Health Organisation. International Nonproprietary Names Programme and Classification of Medical Products [Internet]. World Health Organisation; 2023 [cited 2023 June 27]. Available from: <https://www.who.int/teams/health-product-and-policy-standards/inn/>.
21. The Cochrane Collaboration. Names [Internet]. The Cochrane Collaboration; 2022 [cited 2023 June 27]. Available from: <https://community.cochrane.org/style-manual/names-common-terms-and-terminology/names>.
22. Knowadays. How to Capitalize Titles [Internet]. Knowadays; 2023 [cited 2023 June 27]. Available from: <https://knowadays.com/blog/how-to-capitalize-titles/>.

23. Baines P. Road signs: Why Britain's designs rule [Internet]. The Independent; 2015 [cited 2023 June 27]. Available from: <https://www.independent.co.uk/news/uk/home-news/road-signs-why-britain-s-designs-rule-10466510.html>.
24. Wikipedia. Creative Commons license [Internet]. Wikipedia; 2023 [cited 2023 June 27]. Available from: https://en.wikipedia.org/wiki/Creative_Commons_license.
25. Creative Commons. Attribution-NonCommercial-NoDerivatives 4.0 International [Internet]. Creative Commons; 2023 [cited 2023 June 27]. Available from: <https://creativecommons.org/licenses/by-nc-nd/4.0/>
26. Strunk W, White E. The Elements of Style. 4th ed: Pearson; 1999.
27. Sydney Clinical Skills and Simulation Centre. Improving Patient Care Through Quality Learning & Research [Internet]. Sydney Clinical Skills and Simulation Centre; 2023 [cited 2023 June 27]. Available from: <https://www.scssc.edu.au/>.