The colour of misinformation

Elizabeth Zak

Information Science, University of Iowa, USA
Email: ezak@uiowa.edu

How can colour contribute to the spread of misinformation? When doctors designed a Covid-19 vaccine, both medical organisations and conspiracy organisations designed and disseminated visualisations meant to inform information seekers. While information visualisations effectively conveyed correct health information, misinformation visualisations conversely conveyed incorrect health information. Anti-vaccine misinformation presents a unique danger: if eligible people choose not to receive a vaccine, they are not only harming themselves but slowing herd immunity. One major element of information visualisations, colour, conveys both explicit and implicit messages. Specifically, when used in information visualisations, colour may contribute to the credibility of the information presented. Identifying the colours used in misinformation visualisations will allow information seekers to discern between which visualisations contain information and which contain misinformation. This will curtail the spread of and belief in misinformation.

Received 13 April 2023; revised 01 August 2023; accepted 18 September 2023
Published online: 21 December 2023

Introduction

Information visualisations present data in an effective, user-friendly way. Information visualisation types range from scientific graphs to photographs. Colour is one major element of all types of information visualisations. Colour conveys both implicit and explicit messages. When used effectively, information seekers associate colour with the information it conveys. Often, information seekers first identify the colours used in a visualisation before evaluating other elements such as title or type of graph [1-2]. Misinformation visualisations, or images designed to spread misinformation, are an emerging form of misinformation [3]. Although malicious designers use tools such as Photoshop or deepfakes to manipulate photographs, they use graphic elements such as colour, title and x/y-axis to create misinformation visualisations.

Health-related visualisations present either information or misinformation. One major subject of these visualisations is vaccines. Pro-vaccine information visualisations state that vaccines are safe and prevent deadly diseases. Anti-vaccine misinformation visualisations often argue that vaccines are harmful, cause negative side effects, and contain aluminium or other toxic chemicals [4]. While researchers have found that arguing against the information presented is one method of combatting misinformation, laypeople do not possess these tools [5]. Information literacy and specifically, visual literacy, may prevent the spread of visual misinformation. Information users may also utilise context clues in a visualisation to determine whether a visualisation contains true information or misinformation. Specifically, identifying the colour palette that deceptive users utilise when designing visual misinformation will allow users to identify which visualisations contain misinformation. The colours used for the background and text are important when seeking whether the information conveyed is correct. Evaluating the photos used to convey either the information or misinformation further allows us to identify the motive of someone's visualisation creation. After identifying websites that provided information visualisations about vaccines, twenty information visualisations and twenty misinformation visualisations were obtained. The colours used in each set of visualisations were evaluated.

Background

Current research discussing health information visualisations, health misinformation visualisations, the use of colour in health information visualisations and current concerns in misinformation visualisation were evaluated.

During and after the Covid-19 pandemic, researchers explored infographic use in promoting Covid-19 vaccinations. Vivion *et al.* (2020) surveyed pro-vaccine materials, finding that infographics were both a popular and useful tool in encouraging parents to vaccinate their children. They argued that infographics provide visual support to textual information [6]. Domgaard and Park (2021) argued that health infographics can help information seekers identify anti-vaccine misinformation. After designing and presenting an infographic, they found that information seekers were both better equipped and more confident to identify misinformation [7]. Meuschke *et al.* (2022) found that narrative medical visualisation, visualisations that used storyboards with data visualisations, helped effectively explain disease onset, symptoms and treatment to information seekers [8]. Arguing the need for transparency in medicine, Mandell (2022) developed a visualisation tool meant to help users evaluate information about their patient records [9]. Mendel-Van *et al.* (2018) presented expectant mothers with infographics and videos, finding that while infographics are useful, viewers thought they were boring [10].

Researchers have identified health misinformation visualisations as a major concern. Li *et al.* (2020) discussed YouTube videos and found that a quarter of the most viewed YouTube videos discussing the Covid-19 pandemic were misinformative [11]. Brennen *et al.* (2021) conducted analysis of health misinformation visualisations. They found that although many information seekers associate visual misinformation with deepfakes, misinformation visualisations are often manipulated with simple tools, or composed of pre-existing images taken out of context [12]. Vyas *et al.* (2021) conducted a literature review, finding that health misinformation is difficult to detect. Due to the amount of health information on social media and other platforms, information seekers may struggle with discerning between real information and misinformation [13]. Heley *et al.* (2022) explained that health misinformation visualisations have one of the following functions: "(a) implying inaccurate connections between

verbally and visually presented information; (b) misrepresenting or impersonating authoritative institutions; (c) leveraging visual traditions and conventions of science to suggest the information presented is evidence-based; and (d) providing visual evidence to support a false claim." [14]. Each of these functions will result in distrust of true information. Although researchers agree that more research is necessary in health misinformation visualisations, they differ in their approach.

Information seekers must evaluate colour thoughtfully, as designers use colour may to either convey correct information or misinformation [15-16].

People's emotional responses to colours are important. Kaya and Epps (2004) found that green evoked positive emotions, while red evoked both positive (love) and negative (evil, fight) emotions. Blue also evoked the feelings of comfort and hope [17]. Wilms and Oberfeld (2018) found that saturated and bright colours corresponded to higher participant arousal. Blue was the most preferred colour and was also associated with calmness. Green was also associated with a high calmness state. Red was the most arousing colour, and the most stimulating [18]. Junauskaite *et al.* (2020) found that information seekers associated black with negative emotions. Information seekers also associated red with hate or anger, blue with relief, pink with pleasure, grey with sadness and yellow with joy and amusement. Turquoise was also associated with joy and pleasure [19]. Specific colours convey specific emotions.

Researchers have further explored the importance of brightness in colour perception. Kang (2016) found that bright, warm colours such as magenta, red, yellow, and cyan were more likely to catch and keep information seekers' attention [20]. Bartram *et al.* (2017) found that users linked bright colours to positive emotions and darker colours to negative emotions when evaluating colour palettes. Furthermore, participants associated higher saturated colours with excitement, power, and positivity more than they did lower saturated colours [21]. Szafir (2018) found that understanding colour is important when evaluating a visualisation. They also argued that designers must understand trade-offs between graph elements and colour mappings, and that current colour-encoding models contain limitations [22]. Einakian and Newman (2019) explored the difference between artwork and information visualisations. They found that disharmonious colours, or colours that are different from one another, are more noticeable for viewers rather than colours that are harmonious. They also found that "disharmonious colour combinations also appear more noticeable than low saturated, high lightness, and low lightness colour combinations" (p.152). This shows that disharmonious colour combinations are most effective when designing a memorable graph [23]. Karim *et al.* (2019) also evaluated users' reactions to colour palettes. They found that participants recalled and preferred multi-hue sequential colour maps more than monochromatic or rainbow colour maps. They argued that designers must use multi-hue colour maps when conveying information [24]. Barrera-Leon (2020) identified colour as having the biggest impact on showing a visualisation's subset and proposed that future colour palettes use contrasting colours [25]. Liu (2022) designed a colour encoding method that used colour clustering in photographs to create corresponding colour palettes for infographics [26].

Although visual misinformation is common, it is still underexplored. Specifically, current research identifies visual misinformation as infographics, graphs or photos meant to mislead viewers. Weikmann and Lecheler (2022) argued that visual misinformation differed from textual misinformation in its production, processing, and effects [27]. Because visual misinformation is quicker to process, it is more difficult to disprove. Lauer and O'Brien (2020) explained that deceptive users may use colour in a misinformative graph to attract an information seeker [28]. Singh *et al.* (2020) found that fake news websites often had less-saturated colours in their images. Fake news images were also visually darker and were more likely to contain violence or blood and gore. These dark images proved effective in spreading misinformation [29]. Lisnic *et al.* (2022) explained that improper colour may spread misinformation [30]. Henle *et al.* (2022) argued that more research exploring the colours used in visual

misinformation is necessary [31]. Current research discussing visual misinformation has both identified colour as a means of conveying misinformation. This colour is present in both graphical and photographic misinformation.

Misinformative graphic designers use colour to deceive information seekers [32]. Matatov *et al.* (2018) designed a tool meant to detect visual misinformation. They found that one major sign of visual misinformation is recolouring of an image: changing the colours of a pre-existing image and using it to spread misinformation online. These photo editing techniques may convince information seekers of something untrue [33]. Billiard and Moran (2022) found that the online component of traditional news outlets used neutral, subdued colours such as black and white, while online-only news outlets used bold colours, such as red and yellow. Unfortunately, fake news websites also used bold colours and clashing colour palettes [34]. This may confuse information seekers. Lo *et al.* (2022) identified overuse of colours, indistinguishable colours, and colour-blind unfriendly colours as current examples of colour-based visual misinformation. They also found that an ineffective colour scheme may lead to information seeker confusion [3]. Current research in colour's use in visual misinformation identifies colour as a major element of deception. However, more research is necessary when identifying colour, especially in graphic misinformation.

Based on the current literature, three research questions were identified:

1. Do infographics and misinformative infographics have a similar colour palette?
2. Do the same colours appear in infographics that spread information and misinformation?
3. What are the major colour differences in infographics that contain information and infographics that contain misinformation?

Methodology

Pro-vaccine and anti-vaccine information was selected as the topic, as they have a clear difference between true information and misinformation. The pro-vaccine movement seeks to inform people about the safety of vaccines. The anti-vaccine movement utilises misinformation to convince parents and adults to refuse safe vaccines. The majority of pro-vaccine information is disseminated by medical professionals, while the majority of anti-vaccine misinformation is disseminated by conspiracy theorists [35-36].

The Covid-19 vaccine was identified as the vaccine that both the pro-vaccine and anti-vaccine movement discussed. Johnson *et al.* (2020) discussed vaccine hesitancy present at the beginning of the pandemic: while doctors developed the vaccine, anti-vaccine clusters on social media spread misinformation [37]. Once the vaccine was available, anti-vaccine rhetoric persisted: Pullan and Deb (2021) explained that Google Trends showed vaccine hesitancy when vaccine breakthroughs were announced, as well as when public anti-vaccine sentiment was voiced [38]. After the development of the Covid-19 vaccine, people were sceptical of its effectiveness. Anti-vaccine organisations such as falsely stated that the quick development of the Covid-19 vaccine meant it was unsafe. While the Covid-19 vaccine was in development, health organisations also spread information about its safety, trying to debunk common anti-vaccine myths [39-41]. Current anti-vaccine misinformation includes vaccines contain dangerous ingredients, Covid-19 vaccines cause variants, Covid-19 vaccines cause adverse responses, and Covid-19 vaccines are ineffective. Researchers have debunked these conspiracy theories [42-44]. Unfortunately, in July 2022, the Kaiser Family Foundation found that only 78% of eligible adults received at least one dose of the Covid-19 vaccine [45]. Misinformation regarding the vaccines is

effective and widespread. After two years of an accessible vaccine, people are still hesitant to receive the Covid-19 vaccine and its subsequent boosters.

First, websites that disseminated either information about Covid-19 vaccines or misinformation about Covid-19 vaccines were identified. One website that spread Covid-19 vaccine information and one website that spread Covid-19 vaccine misinformation was selected. Each website was selected based on their popularity and credibility within pro- and anti-vaccine communities. Only infographics that discussed Covid-19 vaccine information or misinformation were used. These infographics, also known as flyers, were meant to either persuade someone of the Covid-19 vaccine's safety or danger. Twenty infographics were obtained from each website. Although the forty infographics presented either pro-Covid-19 vaccine or anti-Covid-19 vaccine arguments, each infographic presented a sub-argument or reasons as to why the vaccines were safe or unsafe. Each of the infographics were composed of at least one pre-existing image, one textual element and one background colour. Each infographic's colours, background colour, colour of text and images used were evaluated. An example of this characterisation is shown in Image 1.

Image 1: An example of characterisation of black text against a yellow background.

Colour was evaluated manually based on the researcher's perception. Certain colours, such as black and white, used by the visualisations were identical. To avoid researcher bias, hex codes, which are universal HTML-specific six-digit combinations of numbers meant to translate to colour, were also utilised [46]. After this cursory evaluation, colours such as blue, red, and yellow were compared with the search result for their hex codes [46]. For similar colours that may have been confused for one another (teal, light blue) a comparison of the hex code for each colour and the colour's appearance in the visualisation was run [46]. Examples of these comparisons are shown in Images 2 and 3.

Image 2: A visual comparison between red in one of the informative infographics (left), red generated by its hex code (center) and red in one of the misinformative infographics (right).

Image 3: A visual comparison of light blue generated by its hex code (left), teal found in an informative infographic (center), and teal generated by its hex code (right).

Results

The colours used in the infographics were identified and descriptive statistics were run on the number of colours used in each infographic. The background colour, and the colour of text used in each visualisation was also evaluated. Finally, the images used in each set of infographics were evaluated.

The infographics from both websites used different colours: white, black, yellow, red, blue, green, orange, teal, gold, pink, dark blue, purple, light blue, and grey. The average number of colours used in each infographic was 4.275, and the median and mode of number of colours used in each infographic was 4. The range of colours used in each infographic was 6.

Colours used in infographics from the pro-vaccine website	Count
White	19
Blue	13
Black	13
Teal	8
Orange	7
Red	7
Green	6
Gold	5
Yellow	3
Dark blue	1
Light blue	1
Grey	1

Table 1: Count of colours used in infographics from the pro-vaccine website.

As summarised in Table 1, the infographics from the pro-vaccine website used 12 different colours: white, blue, black, teal, orange, red, green, gold, yellow, dark blue, light blue, and grey. The most popular colours were white, which appeared 19 times, blue, which appeared 13 times, black, which appeared 13 times, teal, which appeared 8 times, both orange and red, appeared 7 times, green, which appeared 6 times, gold, which appeared 5 times, yellow, which appeared 3 times, dark blue, light blue and grey, each appeared 1 time. The average number of colours used was 4.2, while the median and mode of colours used in each infographic was 4. The range of colours used was 4.

Colours used in infographics from the anti-vaccine website	Count
Black	20
White	19
Yellow	18
Red	16
Blue	7
Green	2
Pink	2
Orange	1
Purple	1
Dark blue	1

Table 2: Count of colours used in infographics from the anti-vaccine website.

As summarised in Table 2, the infographics from the anti-vaccine website used 10 different colours: black, white, yellow, red, blue, pink, green, orange, purple and dark blue. The most popular colours used were black, which appeared 20 times, white, which appeared 19 times, yellow, which appeared 18 times, red, which appeared 16 times, blue, which appeared 7 times, both green and pink appeared 2 times, orange, purple and dark blue, all of which appeared 1 time. The average number of colours used in each

infographic was 4.35 colours, while the median and mode of colours used in each infographic was 4. The range of colours used was 6.

Both websites used assorted colours as their background colours: there was no overarching prominent colour in either website.

Background colours of infographics from the pro-vaccine website	Count
Blue	7
Green	2
Teal	8
White	2
Black	1
Grey	1

Table 3: Count of background colours of infographics from pro-vaccine website.

As shown in Table 3, the infographics from the pro-vaccine website used blue, green, teal, white, black, and grey as their background colours. The most popular background colours were teal, which appeared 8 times, blue, which appeared 7 times, green, which appeared 2 times, white, which appeared 2 times, black, which appeared 1 time and grey which appeared 1 time.

Background colours of infographics from the anti-vaccine website	Count
Yellow	15
White	5
Black	4
Blue	2
Pink	1
Red	1

Table 4: Count of background colours of infographics from anti-vaccine website.

As shown in Table 4, the infographics from the anti-vaccine website used yellow, white, black, blue, pink, and red as their background colours. The most popular background colours were yellow, which appeared 15 times, white, which appeared 5 times, black, which appeared 4 times, blue, which appeared 2 times, red, which appeared 1 time and pink, which appeared 1 time. In the infographics from both the pro- and anti-vaccine websites, some visualisations used more than one colour as their background colour.

The infographics from the pro-vaccine website used white, black, blue, red, yellow, orange and gold as their text colours. The most popular text colours were white, which appeared 20 times, black, which appeared 13 times, blue, which appeared 6 times, red, which appeared 3 times, orange, which appeared 3 times, gold, which appeared 3 times and yellow, which appeared 2 times. The infographics from the anti-vaccine website used black, yellow, white, and red as their text colours. The most popular colours used were black, which appeared 18 times, white, which appeared 14 times, yellow, which appeared 5 times and red, which appeared 3 times. Once again, in the infographics from both the pro- and anti-vaccine websites, some visualisations used more than one colour as their text colour.

The images found in the infographics were further evaluated. All but one infographic contained either a photograph or clipart. The infographics used both photographs and clipart. No two infographics used the same image. However, each set of infographics had a theme. The pro-vaccine infographics contained photos that included happy children, happy adults, clipart meant to represent the ICU, vials of a vaccine,

and a hospital. The anti-vaccine infographics contained photos that included skeletons, germs, needles, children crying, men screaming, and a broken leg. The pro-vaccine infographics used images that associated vaccines with positive feelings, while the anti-vaccine infographics used images that associated vaccines with negative feelings.

Discussion

Discussion of the appearance of the infographics from the pro-vaccine website, the appearance of the infographics from the anti-vaccine website, the similarities and differences in the infographics from the pro-vaccine and anti-vaccine website, and potential means of discerning between information and misinformation is presented below.

The infographics from the pro-vaccine website used colours including blue, teal, green, dark blue, light blue, and grey. Other colours, such as orange, black, white, red, gold, and yellow, were also present. Major background colours included blue, green, teal, and grey. These are predominantly cool colours.

Cool colours are often used by medical organisations and in hospital décor [47]. Not only is blue a popular visualisation colour, but blue conveys knowledge, security, and trust [47-48]. People often associate white with cleanliness [49-50]. Teal, although not a popular visualisation colour, may appear because it conveys tranquillity and communication [51]. Each of these colours may result in a user implicitly trusting the visualisations: using colours that people in the medical profession use provides the visualisations with credibility. The popularity of white and black text colours supports current findings [52-53]. The majority of images used linked the vaccine to positive feelings and emotions, and the absence of the vaccine to negative emotions.

The infographics from the anti-vaccine website used yellow, white, black, blue, pink, and red as their background colours. Yellow, pink, and red are warm colours. They are not typically used by healthcare organisations. While some organisations use orange for their logo, as it encourages change and movement, they typically avoid red and pink [54]. However, some elements of healthcare such as the red plus sign, use the colour red [55]. This may convince people to trust the information. The bright colours used in anti-vaccine infographics contradict Singh's 2020 findings. The background colours of the infographics from the anti-vaccine website were yellow, black, blue, pink and red. Yellow and black were the most popular background colours. Colours such as red, yellow, and black are all often used for biohazard tape [31]. Black and yellow are also used for cigarette warning labels [56]. Furthermore, yellow and red are used to signify caution and danger, respectively. The colours used present an association between vaccines and danger. The colours in anti-vaccine infographics are supported by current findings [52-53, 56]. The anti-vaccine infographics all used images that conveyed negative feelings. These anti-vaccine infographics also used less medical imagery and some images that did not feature medical information.

Both sets of infographics used a similar number of colours: the pro-vaccine infographics used an average of 4.2 different colours, while the anti-vaccine infographics used an average of 4.35 different colours.

Both sets of infographics used similar colours: specifically, yellow, red, black, blue, white, green, dark blue, and orange all appeared in both sets of infographics. However, pro-vaccine infographics also used teal, gold, light blue and grey. Meanwhile, anti-vaccine infographics also used pink and purple. Pro-vaccine infographics used a cooler colour palette, while anti-vaccine infographics used a warmer colour palette.

Both sets of infographics used different background colours: the pro-vaccine infographics used as their background colour, while the anti-vaccine infographics used as their background colour. Once again, the pro-vaccine infographics used teal, blue, green, and grey. The anti-vaccine infographics used yellow, black and red. The pro-vaccine infographics used cooler colours, while the anti-vaccine infographics used warmer colours.

Both sets of infographics used black and white as their text colours. However, the anti-vaccine infographics also used less text colours than the pro-vaccine infographics.

The major difference in image used was positive and negative affect. Overall, the images used in pro-vaccine infographics conveyed positive messages about vaccines, while the images used in anti-vaccine infographics conveyed negative messages about vaccines. Furthermore, the images used in the pro-vaccine infographics also conveyed more pro-science messages, while the images used in the anti-vaccine infographics showed conveyed more anti-science messages. For example, one of the images used in the pro-vaccine infographics was that of a smiling child. One of the images used in the anti-vaccine infographic was a photograph of a broken leg.

The infographics used provided another method of differentiating information and misinformation. Visuals that conveyed information often used infographics that conveyed a positive message, or one that featured medical imagery, while visuals that conveyed misinformation often used infographics that conveyed a negative message or did not feature medical imagery.

One of this study's major findings is discerning between images that convey information and misinformation.

One potential method of identifying visual vaccine misinformation is evaluating the colours. For example, colours unique to the anti-vaccine infographics were warm colours, while colours unique to the pro-vaccine infographics were cool colours. Another signifier may be title: although both pro-vaccine and anti-vaccine infographics used black, white, red, and yellow for their text, pro-vaccine infographics used other colours such as orange, blue and gold for their text. Background colour is another signifier: the most popular background colours for the pro-vaccine infographics were blue and teal, while the most popular background colours for the anti-vaccine infographics were yellow, black, and white. Once again, the pro-vaccine infographics featured cool colours, while the anti-vaccine infographics featured warm colours. Evaluating the images used in infographics is also helpful: if the image is medical and pertinent to discussion of vaccines, then it is more likely to convey true information while images that are not pertinent to discussion of vaccines are more likely to convey misinformation.

Limitations

This study had a few limitations. Each website only contained twenty visualisations that discussed the Covid-19 vaccine. Therefore, although forty visualisations is a relatively small number, the sample size was large enough to evaluate. Further research could analyse the text presented on each visualisation, and the photos used for each visualisation. More research into the colours used in pro- and anti-vaccine infographics is necessary. Furthermore, identifying which colours in pro-vaccine visualisations and anti-vaccine visualisations stand out to viewers is necessary. Because only two websites were selected and evaluated, future research could identify more pro-vaccine and anti-vaccine websites and obtain more visualisations from each website. Further work with a broader selection of visualisations is necessary.

Conclusions

While visual misinformation is an ever-growing threat, information seekers struggle with identifying it. Visual education still lags when discussing the importance of colour in visualisations. However, identifying colour's importance in information visualisations is necessary for information seekers and educators alike. After analysing forty infographics, warm colours, title colour and background colour were identified as potential signifiers that an infographic may contain misinformation. However, more research is necessary. Researchers agree that more exploration into colour's presence and purpose in visualisations is necessary. Unfortunately, colour as an element of persuasion within information visualisations is still underexplored. In an increasingly visual world, research into colour as an indicator of information or misinformation is necessary.

References

1. Lohse GL (1997), Consumer eye movement patterns on yellow pages advertising, *Journal of Advertising*, **26** (1), 61-73.
2. Lin S, Fortuna J, Kulkarni C, Stone M and Heer J (2013), Selecting semantically-resonant colors for data visualization, *Computer Graphics Forum*, **32** (3), 401-410.
3. Lo LY-H, Gupta A, Shigyo K, Wu A, Bertini E and Qu H (2022), Misinformed by visualization: What do we learn from misinformative visualizations?, *Computer Graphics Forum*, **41** (3), 515-525..
4. Milani E, Weitkamp E and Webb P (2020), The visual vaccine debate on Twitter: A social network analysis, *Media and Communication*, **8** (2), 364-375.
5. De Paor S and Heravi B (2020), Information literacy and fake news: How the field of librarianship can help combat the epidemic of fake news, *The Journal of Academic Librarianship*, **46** (5), 102218.
6. Vivion M, Hennequin C, Verger P and Dubé E (2020), Supporting informed decision-making about vaccination: an analysis of two official websites, *Public Health*, **178**, 112-119.
7. Domgaard S and Park M (2021), Combating misinformation: The effects of infographics in verifying false vaccine news, *Health Education Journal*, **80** (8), 974-986.
8. Meuschke M, Garrison LA, Smit NN, Bach B, Mittenentzwei S, Weiß V, Bruckner S, Lawonn K and Preim B (2022), Narrative medical visualization to communicate disease data, *Computers & Graphics*, **107**, 144-157.
9. Mandell GA, Keating MB and Khayal IS (2022), Development of a visualization tool for healthcare decision-making using electronic medical records: A systems approach to viewing a patient record, *Proceedings of the Annual IEEE Systems Conference*, 1-8, Montreal QC (Canada).
10. Mendel-Van Alstyne JA, Nowak GJ and Aikin AL (2018), What is 'confidence' and what could affect it?: A qualitative study of mothers who are hesitant about vaccines, *Vaccine*, **36** (44), 6464-6472.
11. Li HO-Y, Bailey A, Huynh D and Chan J (2020), YouTube as a source of information on COVID-19: a pandemic of misinformation?, *BMJ Global Health*, **5** (5), e002604, 1-6.
12. Brennen JS, Simon FM and Nielsen RK (2020), Beyond (mis)representation: Visuals in COVID-19 misinformation, *The International Journal of Press/Politics*, **26** (1), 277-299.
13. Vyas P, Vyas G and Liu J (2021), Proliferation of health misinformation on social media platforms: a systematic literature review, *Issues in Information Systems*, **22** (3), 73-85.
14. Heley K, Gaysynsky A and King AJ (2022), Missing the bigger picture: The need for more research on visual health misinformation, *Science Communication*, **44** (4), 514-527.
15. Sadiku MNO, Shadare AE, Musa SM and Akujuobi CM (2016), Data visualization, *International Journal of Engineering Research and Advanced Technology*, **2** (12), 11-16.
16. Midway SR (2020), Principles of effective data visualization, *Patterns*, **1** (9), 100141, 1-7.

17. Kaya N and Epps HH (2004), Relationship between color and emotion: A study of college students, *College Student Journal*, **38** (3), 396-405.
18. Wilms L and Oberfeld D (2018), Color and emotion: effects of hue, saturation, and brightness, *Psychological Research*, **82** (5), 896-914.
19. Jonauskaite D, Parraga CA, Quiblier M and Mohr C (2020), Feeling blue or seeing red? Similar patterns of emotion associations with colour patches and colour terms, *i-Perception*, **11** (1), 1-24.
20. Kang X (2016), The effect of color on short-term memory in information visualization, *Proceedings of the 9th International Symposium on Visual Information Communication and Interaction*, 144-145, Dallas TX (USA).
21. Bartram L and Abhisekh P (2017), Affective color in visualization, *Proceedings of the 2017 CHI conference on human factors in Computing Systems*, 1364-1374, Denver CO (USA).
22. Szafir DA (2017), Modeling color difference for visualization design, *IEEE Transactions on Visualization and Computer Graphics*, **24** (1), 392-401.
23. Einakian S and Newman TS (2019), An examination of color theories in map-based information visualization, *Journal of Computer Languages*, **51**, 143-153.
24. Karim RM, Kwon O-H, Park C and Lee K (2019), A study of colormaps in network visualization, *Applied Sciences*, **9** (20), 4228, 1-13.
25. Barrera-Leon L, Corno F and de Russis L (2020), Systematic variation of preattentive attributes to highlight relevant data in information visualization, *Proceedings of the 24th International Conference Information Visualisation (IV)*, 74-79, Melbourne (Australia).
26. Liu S, Tao M, Huang Y, Wang C and Li C (2022), Image-driven harmonious color palette generation for diverse information visualization, *IEEE Transactions on Visualization and Computer Graphics*, 9969167, 1-16.
27. Weikmann T and Lecheler S (2022), Visual disinformation in a digital age: A literature synthesis and research agenda, *New Media & Society*, **25** (12), 3696-3713.
28. Lauer C and O'Brien S (2020), The deceptive potential of common design tactics used in data visualizations, *Proceedings of the 38th ACM International Conference on Design of Communication*, 27, 1-9.
29. Singh VK, Ghosh I and Sonagara D (2021), Detecting fake news stories via multimodal analysis, *Journal of the Association for Information Science and Technology*, **72** (1), 3-17.
30. Lisnic M, Polychronis C, Lex A and Kogan M (2023), Misleading beyond visual tricks: How people actually lie with charts, *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, 817 (1-27), Hamburg (Germany).
31. Henle J (2019), Red vs. Yellow Barricade Tape – https://baileysafety.com/red-vs-yellow-barricade-tape/ [last accessed 20 March 2023].
32. Pandey AV, Rall K, Satterthwaite ML, Nov O and Bertini E (2015), How deceptive are deceptive visualizations? An empirical analysis of common distortion techniques, *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 1469-1478, Seoul (South Korea).
33. Matatov H, Bechhofer A, Aroyo L, Amir O and Naaman M (2018), DejaVu: A system for journalists to collaboratively address visual misinformation, *Proceedings of Computation + Journalism Symposium*, 1-5, Miami FL (USA).
34. Billard TJ and Moran RE (2022), Designing trust: Design style, political ideology, and trust in "fake" news websites, *Digital Journalism*, **11** (3), 519-546.
35. Hussain A, Ali S, Ahmed M and Hussain S (2018), The anti-vaccination movement: a regression in modern medicine, *Cureus*, **10** (7), e2919, 1-6.
36. Hoffman BL, Colditz JB, Shensa A, Wolynn R, Taneja SB, Felter EM, Wolynn T and Sidani JE (2021), #DoctorsSpeakUp: Lessons learned from a pro-vaccine Twitter event, *Vaccine*, **39** (19), 2684-2691.
37. Johnson NF, Velásquez N, Restrepo NJ, Leahy R, Gabriel N, El Oud S, Zheng M, Manrique P, Wuchty S and Lupu Y (2020), The online competition between pro-and anti-vaccination views, *Nature*, **582**, 230-233.
38. Pullan S and Dey M (2021), Vaccine hesitancy and anti-vaccination in the time of COVID-19: A Google Trends analysis, *Vaccine*, **39** (14), 1877-1881.

39. Le TT, Cramer JP, Chen R and Mayhew S (2020), Evolution of the COVID-19 vaccine development landscape, *Nature Reviews Drug Discovery*, **19** (10), 667-668.
40. Li M, Wang H, Tian L, Pang Z, Yang Q, Huang T, Fan J, Song L, Tong Y and Fan H (2022), COVID-19 vaccine development: milestones, lessons and prospects, *Signal Transduction and Targeted Therapy*, **7** (1), 146, 1-32.
41. Soeters HM, Doshi RH, Fleming M, Adegoke OJ, Ajene U, Aksnes BN, Bennett S, Blau EF, Carlton JG, Clements S, Conklin L, Dahlke M, Duca LM, Feldstein LR, Gidudu JF, Grant G, Hercules M, Igboh LS, Ishizumi A, Jacenko S, Kerr Y, Konne NM, Kulkarni S, Kumar A, Lafond KE, Lam E, Longley AT, McCarron M, Namageyo-Funa A, Ortiz N, Patel JC, Perry RT, Prybylski D, Reddi P, Salman O, Sciarratta CN, Shragai T, Siddula A, Sikare E, Tchoualeu DD, Traicoff D, Tuttle A, Victory KR, Wallace A, Ward K, Wong MKA, Zhou W, Schluter WW, Fitter DL, Mounts A, Bresee JS and Hyde TB (2022), CDC's COVID-19 international vaccine implementation and evaluation program and lessons from earlier vaccine introductions, *Emerging Infectious Diseases*, **28** (S1), S208-S216.
42. Rittle C (2022), COVID-19 vaccine hesitancy and how to address it, *Workplace Health & Safety*, **70** (2), 56-62.
43. Kreps SE, Goldfarb JL, Brownstein JS and Kriner DL (2021), The relationship between US adults' misconceptions about COVID-19 vaccines and vaccination preferences, *Vaccines (Basel)*, **9** (8), 901, 1-8.
44. Piccaluga PP, Di Guardo A, Lagni A, Lotti V, Diani E, Navari M and Gibellini D (2022), COVID-19 vaccine: between myth and truth, *Vaccines (Basel)*, **10** (3), 349, 1-24.
45. Ndugga N, Hill L, Artiga S and Haldar S (2022), Latest data on COVID-19 vaccinations by race/ethnicity [https://www.kff.org/coronavirus-covid-19/issue-brief/latest-data-on-covid-19-vaccinations-by-race-ethnicity/ – last accessed 20 March 2023].
46. Color Hex Color Codes [https://www.color-hex.com/ – last accessed 20 March 2023].
47. Blake J (2014), Why are medical websites usually white and blue? [https://onextrapixel.com/why-are-medical-websites-usually-white-and-blue/ – last accessed 20 March 2023].
48. Pras PG (2017), Why most medical logos are blue? [https://doctormultimedia.com/medical-logos-blue/ – last accessed 20 March 2023].
49. Cerrato H (2012), The meaning of colors, *The Graphic Designer*. [https://blocs.xtec.cat/gemmasalvia1617/files/2017/02/the-meaning-of-colors-book.pdf – last accessed 20 March 2023].
50. Smollar D (1985), Hospitals changing colors to speed healing process [https://www.latimes.com/archives/la-xpm-1985-11-24-me-1688-story.html – last accessed 20 March 2023].
51. Canva (2022), Everything about the color teal [https://www.canva.com/colors/color-meanings/teal/ – last accessed 20 March 2023].
52. Huang W and Tan CL (2007), A system for understanding imaged infographics and its applications, *Proceedings of the 2007 ACM Symposium on Document Engineering*, 9-18, Winnipeg MB (Canada).
53. Wansink B and Robbins R (2016), Which design components of nutrition infographics make them memorable and compelling?, *American Journal of Health Behavior*, **40** (6), 779-787.
54. Babin SE (2013), Color theory: The effects of color in medical environments, *Honors College Thesis*, University of Southern Mississippi (USA).
55. Hutchinson JF (1989), Rethinking the origins of the Red Cross, *Bulletin of the History of Medicine*, **63** (4), 557-578.
56. Lempert LK and Glantz SA (2016), Implications of tobacco industry research on packaging colors for designing health warning labels, *Nicotine & Tobacco Research*, **18** (9), 1910-1914.