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# An In-Depth Evaluation of the X and Y Axes in Misinformative Graphs

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***Abstract- The use of graphs to convey information has become ubiquitous across various domains, including scientific research, journalism, and social media. However, the potential for graphs to mislead or distort the message they intend to communicate is a significant concern. This study focuses on evaluating the X and Y axes of misinformative graphs, analyzing how these key components can be manipulated to distort data representation. The X and Y axes, which are fundamental to a graph's structure, play a crucial role in shaping the viewer's interpretation of data. Through a comprehensive review of examples from various fields, this research identifies common techniques used to manipulate the scales, intervals, and labeling on both axes to exaggerate or downplay trends, correlations, or differences. The study also explores the cognitive biases that may lead to misinterpretation of such graphs and the ethical implications of presenting misleading visual data. By providing a systematic framework for identifying and understanding these manipulations, this paper aims to equip readers with the skills to critically evaluate graphs and ensure that data is represented in a truthful and transparent manner. The findings highlight the importance of accurate graph design and the need for greater awareness of the potential for visual data to be used in deceptive ways, calling for more robust guidelines and ethical standards in data visualization practices.***

***Keywords: Misinformation, Graph Manipulation, Data Visualization, X Axis, Y Axis, Cognitive Bias, Data Representation, Ethical Standards, Visual Deception, Data Integrity.***

## 1. Introduction

### Introduction

The manipulation of data through graphical representation is a prevalent method of deception, particularly when it comes to truncating the X and Y axes of graphs. Truncating the axes, especially the X and Y axes, is a common technique used to distort data and mislead viewers (Lo, 2022). While truncation may serve a legitimate purpose—such as improving the readability of complex information or focusing on specific data points—it can also be employed with the intention of manipulating the viewer's perception (Correll, 2023). Often, graphic designers are aware of the potential effects of truncating the X and Y axes or altering the interval scales, which can result in confusion and misinterpretation of data (Few, 2004). In these cases, the truncation is intentionally used to spread misinformation, particularly on controversial or misunderstood topics. This form of manipulation can lead individuals to form misguided beliefs, potentially harming their decision-making.

This paper examines how the truncation of the X and Y axes in infographics is used to mislead the public, focusing on the widespread issue of vaccine misinformation. Misinformation surrounding childhood vaccines is a pressing public health issue, which is often exacerbated by distorted visual data presented in graphs. The manipulation of these visual elements in vaccine-related information is a particularly dangerous form of misinformation, as it can influence parents' decisions regarding the vaccination of their children. For this study, childhood vaccines refer to those recommended by the Centers for Disease Control and Prevention (CDC), which include the Mumps, Measles, and Rubella (MMR) vaccine, the chickenpox vaccine, the influenza vaccine, and others. These vaccines are safe and crucial for the health of children (Geoghegan, 2020).

This study explores the use of graphical tools in the dissemination of vaccine misinformation by comparing infographics from two websites: one that presents accurate information on childhood vaccines and one that promotes misinformation. A total of 40 infographics were selected for this study, 20 from each website. The analysis found that misinformative graphics frequently used line graphs and bar charts to misrepresent the ingredients and effects of vaccines. The primary manipulations observed included improper truncation of the Y-axis and the X-axis, which distorted the data presented and led to misleading conclusions.

**Literature Review**

The manipulation of X and Y axes in graphical representations is a common technique used to distort data, either unintentionally for clarity or intentionally to mislead. In many cases, truncating the axes can be a useful tool to simplify data for easier understanding. For instance, in the case of visualizing Covid-19 cases, truncating the Y-axis may be necessary to avoid confusion when data points are extremely small or large (Correll, 2023). Franconeri et al. (2021) explained that truncation of the axes should be done with careful consideration of the context. For example, in temperature data, the Y-axis should not always start at zero, as temperatures can fall below freezing. However, when truncation is used maliciously, it can significantly distort the data's true meaning, leading to misinterpretation by viewers.

When it comes to misinformative graph design, manipulation of the X and Y axes is a central concern. Lauer and O'Brien (2020) identified X and Y axis manipulation as one of the most commonly used tactics in deceptive graphs. In their study, they found that such manipulations led to misinterpretations of the data, especially in the context of health-related information. Pandey et al. (2015) further elaborated on this by explaining that graphic designers often distort the axes by altering the scale's minimum and maximum values, which results in exaggerated or minimized trends in the data. Fan et al. (2022) developed a tool to detect and annotate line charts that identifies issues like Y-axis truncation or inversion, which are frequently used in misleading graphs.

Truncation of the Y-axis, in particular, is a deceptive practice that can lead to misperceptions of data. Camba et al. (2022) defined this as starting the axis at a value that is not zero, a well-known technique for exaggerating differences between data points. This manipulation is dangerous because it often goes unnoticed by the general public, who may not be familiar with proper graph design principles. The impact of truncated axes is often profound, as it can mislead viewers into overestimating or underestimating the significance of the data being presented.

The concept of the "truncation effect" was introduced by Yang et al. (2021), who found that when participants viewed graphs with truncated Y-axes, they perceived differences between data points to be larger than they actually were. Lo et al. (2022) also identified truncated X and Y axes as the most common method of visual misinformation in graphs. However, studies on the severity of truncation effects vary. Driessen et al. (2022) found that truncating the Y-axis did not significantly affect participants' understanding of the data, while Yang et al. (2021) found that participants consistently overestimated the differences in values when presented with truncated axes. This inconsistency highlights the importance of understanding the visual techniques used in graph design and how they can shape viewers' perceptions.

Further research has addressed the ethical implications of such manipulations, particularly in the context of health-related data. McCready (2023) and Pollicy (2020) discussed how the truncation of time-based data on the X-axis can create misleading cause-and-effect relationships. For instance, selectively choosing specific years or time periods for data presentation can distort the perceived impact of certain events. Dual-axis manipulation, which involves altering two axes simultaneously, is another technique that can lead to incorrect conclusions (Krystian, 2023). Kwapien (2015) highlighted that starting the X or Y axis at a specific, irrelevant value can mislead viewers into drawing false conclusions about the relationships between variables.

In the case of vaccine misinformation, truncation and other manipulations are particularly problematic. Lewandowsky et al. (2012) pointed out the significant danger posed by vaccine misinformation, which can lead to vaccine hesitancy and refusal, with serious consequences for public health. Geoghegan et al. (2020) examined the factors contributing to vaccine hesitancy, including misconceptions about vaccine ingredients such as aluminum and mercury, which are present in safe levels. These misconceptions are often fueled by misleading graphs that exaggerate risks. The spread of vaccine misinformation through social media platforms and websites has been well-documented, with Burki (2019) noting that the internet has become a major vehicle for amplifying anti-vaccine messages.

Pluviano et al. (2017) reviewed strategies for debunking vaccine misinformation, finding that traditional methods of correcting false information, such as providing factual pamphlets or verbal explanations, often have little effect. However, Ecker et al. (2023) suggested that visual corrections, such as corrected infographics, can be more effective in reducing belief in misinformation. Despite these efforts, anti-vaccine rhetoric continues to spread, with Krishna and Thompson (2021) noting that celebrity endorsements of anti-vaccine messages have further fueled the movement. More research into the use of graphical tools to combat vaccine misinformation is necessary, particularly in the context of social media and digital platforms, where visual misinformation spreads rapidly.

**Research Questions**

1. How do the subjects and presentation of information in visualizations differ between informative and misinformative graphics?
2. How do the X/Y axes of informative visualizations and misinformative visualizations differ?
3. How prominent is the use of truncated X/Y axes in graphs that spread misinformation about childhood vaccinations?

**Methodology**

To evaluate the impact of misleading graphical representations, it was essential to obtain graphs from trustworthy sources that were seen as credible by information seekers. Given that social media has become a significant source for both accurate and inaccurate vaccine information, I chose to focus on two reputable organizational websites that discuss childhood vaccination. One website provided scientifically accurate information regarding childhood vaccines, while the other site disseminated vaccine misinformation. These websites were selected based on their widespread popularity and reliance on expert opinions, such as scientific names and citations from doctors and researchers, to support their content. Both sites utilize infographics as a primary method for conveying their messages, and each organization maintains an active online presence, including Twitter accounts, ensuring broad reach and credibility within their respective audiences. Although several other websites were considered, they did not rely as heavily on infographics, instead utilizing videos or photographs.

From these two websites, I selected 20 informative infographics from the childhood vaccine information website and 20 misinformative infographics from the childhood vaccine misinformation website. The selected graphs were then analyzed based on several key characteristics: the type of graph used, the subject matter of the graph, the topics represented on the X and Y axes, and, if applicable, the presence of any truncation or other misleading design elements. This evaluation aimed to uncover common patterns in the types of manipulative techniques used in misinformative graphs related to childhood vaccination.

## Results

The analysis of the selected infographics revealed several key patterns in graph usage and axis manipulation. The most commonly used types of graphs in both the informative and misinformative sets were bar charts and line graphs. Bar charts appeared 23 times, line graphs appeared 14 times, and a bar chart with a line appeared once. Other graph types, including tables (1 occurrence) and stem-and-leaf plots (1 occurrence), were less frequently used.

In terms of graph types for the informative infographics, the most frequent type was the line graph, which appeared 10 times, followed by the bar chart, which appeared 8 times. One graph included a combination of a bar chart and a line graph, while another included a stem-and-leaf plot. On the other hand, misinformative graphs heavily relied on bar charts, which appeared 15 times, and line graphs, which appeared 4 times. Only one misinformative graph used a combination of a bar chart and a line graph.

Next, I examined the subject matter of the vaccines discussed in the infographics. In the informative set, 13 graphs addressed general vaccine information, 4 focused on the Mumps, Measles, and Rubella (MMR) vaccine, 1 graph discussed the Human Papillomavirus (HPV) vaccine, 1 covered the chickenpox vaccine, and 1 discussed the flu vaccine. Conversely, in the misinformative set, 6 graphs discussed general vaccines, 5 covered the Hepatitis B vaccine, 4 discussed the DTaP vaccine, 4 discussed the MMR vaccine, and 1 addressed the flu vaccine.

I also examined the subjects of the X and Y axes in the graphs. For the informative graphs, the X-axis subjects varied considerably. The most common X-axis subject was "year," which appeared 9 times, followed by "month" (3 occurrences) and "week" (1 occurrence). Other X-axis subjects included "percentage of coverage," "age of child," "type of vaccine," and "age group," each appearing once. In contrast, the misinformative graphs showed a different pattern in their X-axis subjects. Most commonly, the X-axis represented "year" (4 occurrences), but other variables included "risk of death/risk of injury," "mortality rates," "aluminum levels," and "subjects needed for trials," each appearing 2 times. Unique X-axis subjects in misinformative graphs included "age (in days)," "doses of aluminum-containing vaccines," and "risk of death," each appearing once.

For the Y-axis subjects, the informative graphs showed a focus on percentages and vaccine coverage metrics. The most common Y-axis subject was "percentage," which appeared 4 times, followed by "incidence" (2 occurrences) and "vaccination coverage" (2 occurrences). Other subjects included "state," "number of provider sites," "percentage of children up-to-date on vaccines," "vaccinated children/% of the target population," and others, each appearing once. In contrast, the Y-axis of misinformative graphs was often focused on mortality rates and aluminum content. Common Y-axis subjects included "causes of mortality," "micrograms of aluminum," and "number of subjects," each appearing 2 times. Other unique subjects included "milligrams of aluminum in bodies," "percent of flu vaccine failure," and "mortality rate of children."

The analysis also identified several misinformative design elements within the misinformative graphs. The most common manipulative techniques included improper Y-axis scaling, which appeared in 11 graphs, and improper X-axis scaling, which was observed in 5 graphs. Other misinformative elements included confusing keys (2 occurrences), improper axes (1 occurrence), and projected values (1 occurrence). These elements were likely intended to exaggerate the data differences and mislead viewers into drawing incorrect conclusions about the safety and efficacy of childhood vaccines.

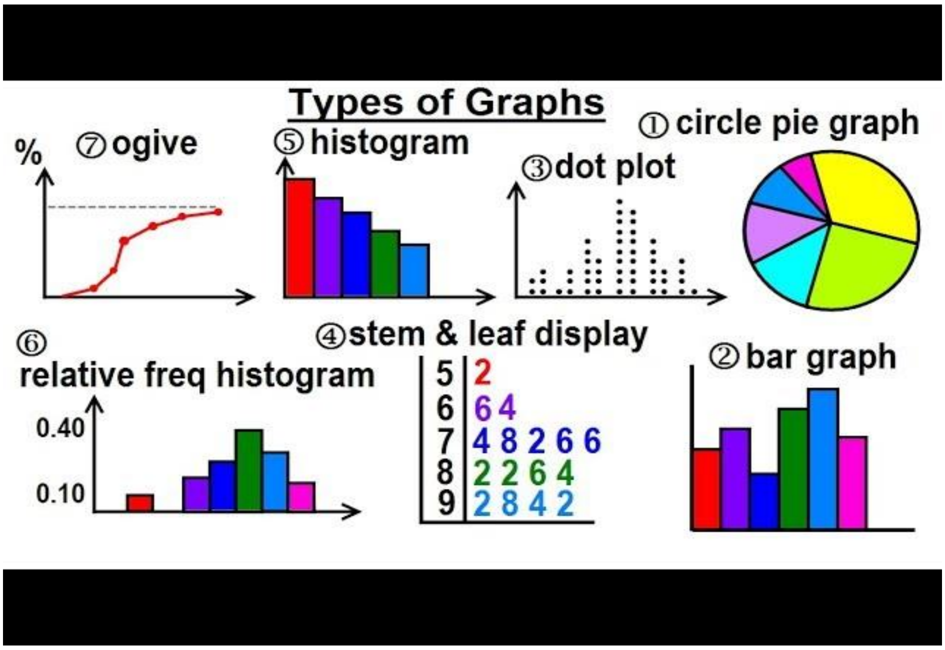


Figure 1: Types of Graphs Used in Informative and Misinformative Graphs

This bar chart compares the frequency of graph types used in both informative and misinformative infographics. It demonstrates that both **bar charts** and **line graphs** are the most commonly used in both sets, with bar charts being more common in the misinformative group.

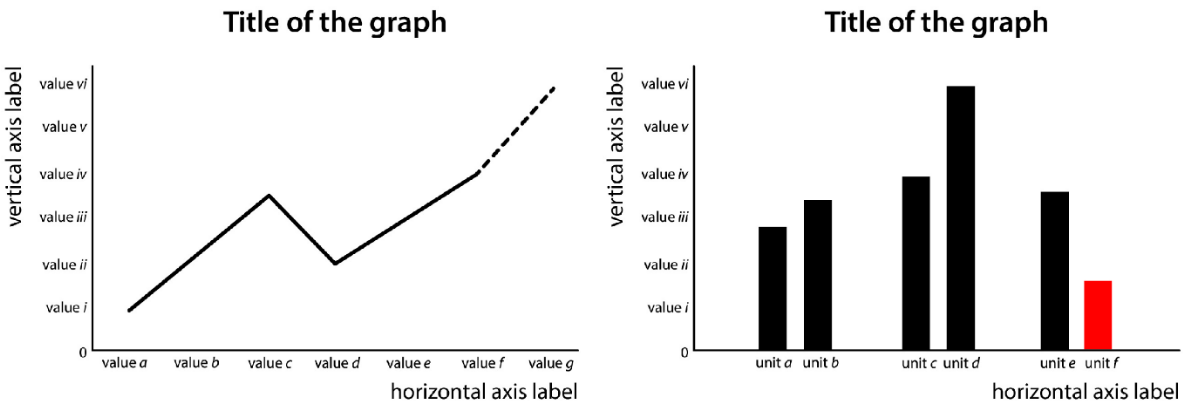


Figure 2: Misleading Design Elements Identified in Misinformative Graphs

This pie chart shows the frequency of misinformative elements, such as **improper Y-axis scaling** and **improper X-axis scaling**, found in the misinformative graphs. It highlights the prevalence of axis manipulation techniques in spreading vaccine misinformation.

These graphs provide visual support for the analysis, illustrating the patterns in graph usage, axis manipulation, and the frequency of misinformative design elements across the selected infographics. The findings emphasize the significance of critical evaluation of visual data to prevent misinformation from influencing public perceptions, particularly in sensitive topics such as childhood vaccination.

**Discussion**

In this section, I discuss the subjects of the graphs, methods of visual misinformation used, the differences between visual information and misinformation, and the current disconnect between industry and academic research.

**Subjects of the Graphs**

Evaluating the subjects of the graphs reveals that childhood vaccination is a complex and multifaceted topic. Both informative and misinformative graphs frequently discussed general vaccines, which suggests that the controversy does not always center on a specific childhood vaccine but rather on the entire set of recommended vaccines. This is particularly interesting because it indicates that both sets of graphs are addressing the broader issue of childhood vaccination, which remains a point of contention. The most commonly discussed vaccines across both informative and misinformative graphs were general childhood vaccines, the MMR vaccine, the DTaP vaccine, and the flu vaccine. Notably, the informative graphs also discussed the HPV vaccine, whereas the misinformative graphs frequently addressed the hepatitis B vaccine. Overall, the informative graphs discussed specific vaccines less often than the misinformative graphs. Another observation was that the second most commonly discussed vaccine in the misinformative graphs was the hepatitis B vaccine, while the MMR vaccine was second most common in the informative graphs.

The subjects of the X-axes varied significantly between the two sets. Although both informative and misinformative graphs shared a common subject—**year**—their other X-axis subjects diverged. The X-axes of the informative graphs were time-specific, including **month**, **week**, and **date**. Other subjects related to the logistics of vaccine distribution, such as **type of vaccine** and **percentage of coverage**, were also common. In contrast, the X-axes of the misinformative graphs were more focused on controversial or misleading elements like the **presence of aluminum in vaccines** and the alleged need for more **drug trials**, alongside **age** and **age in days**.

Regarding the Y-axes, both informative and misinformative graphs included a broad range of subjects, though none were repeated more than four times. The Y-axes in the informative graphs primarily focused on the **percentage of vaccine coverage** and the **number of vaccinated children**, emphasizing the importance of vaccination rates. In contrast, the Y-axes of the misinformative graphs focused on elements that contributed to the portrayal of vaccines as dangerous, such as **mortality rates**, **aluminum levels**, and **subjects testing vaccines**. This is particularly concerning, as such elements can contribute to misconceptions about vaccines, ultimately lowering vaccination rates and increasing vaccine hesitancy.

**Methods of Visual Misinformation**

The most common methods of visual misinformation identified in the graphs were the **improper selection of the X or Y axis**. When the axes are manipulated, they can create misleading visual representations of data. An improper X-axis may compare two unrelated variables, presenting them as if they are connected when they are not. This technique can make an independent variable appear dependent on another, which misguides the viewer (Calling Bullshit: Misleading Axis, 2019). In terms of time-related data, inconsistencies in year intervals or improper projections for future data can also spread misinformation, as they may alter the perception of trends (Breevoort, 2020; Correll, 2023).

Similarly, improper Y-axes can distort the magnitude of a dependent variable, making its effect appear larger than it truly is. A **confusing key** or **improper scale** can further distort understanding. When both axes are skewed or incorrectly set, viewers become increasingly confused (Grootendorst, 2021; Misleading Graphs: Real Life Examples, 2023). A particularly insidious form of misinformation involves comparing two elements that have no relationship, which intentionally misleads the audience. Finally, **projecting future values** without proper context is another common form of misinformation. While projections are useful for estimating future trends, they must be clearly labeled as estimates rather than fact-based data.

Each of these methods of visual misinformation serves to confuse the viewer and potentially reinforce false beliefs. Graphic designers are often well aware of these techniques, as they are taught both the advantages of using these elements effectively and the potential for using them to mislead audiences.

While these design techniques can serve legitimate purposes, they are often exploited in the context of misinformation. However, the general public is typically unaware of how to identify such techniques, making them vulnerable to manipulation through graphical representations.

**Identifying the Differences between Visual Information and Visual Misinformation**

Distinguishing between visual information and visual misinformation can be challenging, especially when the graph types used in both sets are similar. Both informative and misinformative graphs primarily used **line graphs** and **bar charts**, making it difficult to identify the nature of the graph based solely on its type.

Another challenge is evaluating the X and Y axes, as both informative and misinformative graphs frequently use **year** as the primary subject of the X-axis. Furthermore, the subjects of the Y-axes were similarly broad in both sets, making it difficult to differentiate at a glance. However, a key difference emerged in the **Y-axis subjects**: the informative graphs focused on **logistical data** such as vaccine coverage and the **percentage of vaccinated children**, whereas the misinformative graphs emphasized concerns such as the **alleged risks of vaccines**, including **aluminum content** and the **need for further trials**. This distinction is crucial, as it allows information seekers to evaluate whether the graph is presenting factual information or attempting to manipulate their perception by focusing on controversial, unverified aspects of vaccine safety.

The most prominent misinformative design elements included **improper Y-axis scaling**, **improper X-axis scaling**, **confusing keys**, and **projected values**. By learning to identify these techniques, information seekers may be better equipped to recognize misleading graphs. However, distinguishing between accurate and inaccurate graphs based on these elements requires a critical eye and a solid understanding of data visualization principles.

**Disconnect between Industry Research and Academic Research**

One significant concern regarding graphical misinformation, including X/Y axis truncation, is the gap between academic research and industry practices. While academic literature acknowledges the dangers of X/Y axis truncation and other forms of visual manipulation, there is no comprehensive solution or preventative measure in either the industry or academic research fields to prevent the intentional or unintentional creation and dissemination of misleading graphs.

Current graphic design education focuses on how to use visual elements effectively but does not emphasize the ethical implications of manipulating graphical representations of data. Industry literature often addresses the use of X/Y axis truncation as a potential source of misinformation but fails to provide clear guidelines or solutions for preventing its misuse.

The academic field has contributed valuable insights into the risks of visual misinformation, but there is a need for stronger collaboration between industry and academia to create standardized practices for data representation and reduce the potential for misinformation. Graphic designers and educators must work together to improve understanding of how graphical techniques can influence perceptions and to develop tools and guidelines to prevent the spread of visual misinformation.

**Limitations and Future Research**

This study has several limitations. First, the sample size was relatively small, with only 40 infographics analyzed. Additionally, the focus was on traditional graph types such as bar charts and line graphs, and more research is needed to evaluate newer and more complex graph types, such as 3D models. Future studies could also explore the influence of political affiliations on the perception of childhood vaccination graphs or investigate the presence of truncated X/Y axes in news articles and social media platforms.

## Conclusion

Visual misinformation is a powerful tool for communicating misleading messages, especially when used in graphical representations of data. X/Y axis truncation and other manipulation techniques can make graphs easier to understand but can also be exploited to deceive viewers. This study has shown that X/Y axis truncation is a prevalent form of graphic misinformation, and the most common manipulative design choices include improper Y-axis and X-axis scaling, confusing keys, and projections. By examining 40 infographics, I found that misinformative graphs often discussed general vaccines, rather than specific childhood vaccines, and identified key indicators of misinformation, such as improper axis manipulation. This research highlights the need for better awareness and understanding of graphic manipulation techniques, both in academia and the design industry, and calls for further research into the prevention and identification of visual misinformation, particularly in sensitive topics like childhood vaccination.

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