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FROM DATA TO DECISIONS: A PRACTICAL FRAMEWORK FOR ACCURATE, ETHICAL AND ACCESSIBLE GRAPHICAL PRESENTATION IN STATISTICAL ANALYSIS

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ABSTRACT

Graphical presentation is a central component of statistical analysis because it converts numerical information into visual evidence that can reveal distribution, comparison, trend, association and uncertainty. However, graphs can also mislead when the chart type, scale, denominator, colour, annotation or level of aggregation is inappropriate. This applied methodological review examines the selection, design and interpretation of common statistical graphics, including bar charts, dot plots, histograms, box plots, line charts, scatter plots, maps and uncertainty displays. Evidence from statistical, cognitive and visual-communication literature is synthesised to explain why visual effectiveness depends on matching the graph to the research question and data structure rather than on decoration. The review shows that bar and dot charts support categorical comparison; histograms, density plots and box plots reveal numerical distributions; line charts display ordered change over time; scatter plots examine relationships; and confidence-interval plots communicate estimate precision. Pie charts and three-dimensional effects are often less effective because angle, area and perspective are harder to compare accurately. The paper proposes a Graph Selection-Design-Interpretation Framework built around seven principles: question-data alignment, truthful scales, denominator transparency, visible uncertainty, accessibility, reproducibility and ethical communication. Three technical tables provide guidance on chart selection, visual-integrity auditing and public-health dashboard design. The paper concludes that graphical presentation is not a cosmetic final step but an analytical method that shapes interpretation and decision-making. High-quality graphs should be accurate, simple, accessible and reproducible, while showing enough context to prevent false certainty or misleading comparison.

KEYWORDS: Data visualisation; statistical graphics; graph design; scientific communication; biostatistics; public health; visual integrity.

I. INTRODUCTION

Statistical graphics are among the most efficient tools for exploring, analysing and communicating data. A well-designed graph can reveal patterns that are difficult to detect in a table, including skewness, outliers, abrupt changes, clustering, non-linearity and subgroup differences. Graphs are therefore used throughout the research process: during data cleaning, exploratory analysis, model diagnosis, interpretation and dissemination.

Visual presentation is powerful precisely because people make rapid judgments from position, length, direction, colour and shape. That strength also creates risk. A truncated axis can exaggerate a minor difference, unequal time intervals can suggest a false trend, and a map can imply geographic risk where differences are actually driven by population size. Graphical choices are therefore statistical and ethical decisions rather than matters of style alone.

In public health, visualisation influences outbreak response, programme monitoring, budget allocation and communication with communities. Line charts may show whether incidence is increasing; forest plots may display uncertainty around intervention effects; maps may identify service gaps; and control charts may signal unusual variation. These tools are valuable only when the underlying definitions, denominators, time periods and sources are clear.

A. Problem Statement

The increasing availability of software has made graph production easy but has not guaranteed valid design. Default software settings often encourage clutter, excessive colour, inappropriate three-dimensional effects or automatic scales that are poorly suited to the analytical question. Researchers may also choose familiar chart types without considering whether the data are categorical, continuous, longitudinal, spatial or multivariable.

The central methodological problem is the mismatch between visual form and analytical purpose. A graph may be technically correct yet still mislead by hiding uncertainty, combining incompatible denominators, omitting missing data or overemphasising small differences. Poor design can therefore distort evidence even when the underlying calculations are accurate.

B. Aim, Objectives and Research Question

The aim of this review is to critically examine graphical methods used in statistical analysis and to develop a practical framework for accurate, ethical and accessible visual communication.

i. Classify the principal types of statistical graphs according to data structure and analytical purpose.
ii. Explain how graph design influences the interpretation of distribution, comparison, trend, association and uncertainty.
iii. Identify common visual distortions and ethical risks in statistical communication.
iv. Assess the role of graphical presentation in research, public-health decision-making and communication with non-technical audiences.
v. Propose practical standards for graph selection, accessibility, reproducibility and review.

The guiding question is: How can researchers select and design statistical graphics that preserve accuracy, improve understanding and support responsible decision-making?

II. MATERIALS, METHODS AND TECHNICAL PROCEDURES

A. Review Design

An applied methodological review was undertaken to synthesise established principles from statistics, epidemiology, cognitive science and data visualisation. The purpose was not to compare a single intervention effect but to identify design principles that apply across research and policy settings.

B. Evidence Sources

Sources included standard texts on statistical graphics, categorical and medical statistics, research design and scientific visual communication. Guidance from professional and public-health organisations was also considered where it addressed truthful scales, accessibility, uncertainty and reporting.

C. Analytical Approach

Graphical methods were organised around five analytical tasks: comparison, distribution, change over time, relationship and composition. Each graph type was evaluated according to the variables it can represent, the visual judgment it requires, its strengths, common misuse and suitability for technical or public audiences.

D. Quality Criteria

Visual quality was assessed using seven principles: alignment between question and chart; accurate scale and geometry; clear denominators; visible uncertainty; minimal unnecessary decoration; accessibility across devices and visual abilities; and reproducibility from documented data and code.

E. Limitations

This paper provides methodological guidance rather than a systematic review of every visualisation technique. Interactive dashboards, animated graphics and highly specialised plots are discussed only where they illustrate general principles. Effectiveness may also vary by audience, task and medium, so visual testing with intended users remains important.

III. RESULTS AND TECHNICAL FINDINGS

A. Matching Graph Type to Analytical Purpose

The strongest graphs align the visual structure with the question. Position along a common scale is generally easier to compare accurately than angle, area or volume. For this reason, dot plots and bar charts often support clearer categorical comparison than pie charts, while two-dimensional plots are usually preferable to three-dimensional displays.

Table 1. Selection of statistical graphics by data type and analytical purpose

Analytical purpose	Data structure	Preferred graphic	Main strength	Common misuse	Recommended alternative
Compare categories	One categorical variable with counts, rates or percentages	Dot plot or bar chart	Accurate comparison of position or length	3-D bars, inconsistent baselines and excessive categories	Sorted horizontal dot plot

Analytical purpose	Data structure	Preferred graphic	Main strength	Common misuse	Recommended alternative
Show distribution	One continuous variable	Histogram, density plot or box plot	Reveals shape, spread, skewness and outliers	Arbitrary bin widths or a box plot used alone for multimodal data	Histogram plus summary statistics
Show change over time	Ordered repeated observations	Line chart	Displays direction, timing and rate of change	Connecting unrelated categories or using unequal intervals without notice	Point-range chart for irregular observations
Examine relationship	Two continuous variables	Scatter plot	Shows form, direction, strength and outliers	Inferring causation from correlation or hiding overplotting	Scatter plot with transparency, jitter or smoothing
Compare estimates	Point estimates with uncertainty	Forest or interval plot	Communicates magnitude and precision together	Displaying estimates without confidence intervals	Dot-and-whisker plot
Show composition	Few parts of one whole	Stacked bar or 100% stacked bar	Shows part-to-whole comparison	Pie charts with many slices or multiple pies	Ordered stacked bar with labels
Show spatial pattern	Geographic rates or counts	Choropleth or proportional-symbol map	Locates geographic variation	Mapping counts without population denominators	Rate map with uncertainty or small-area smoothing
Monitor process variation	Repeated operational measurements	Run or control chart	Distinguishes common from unusual variation	Treating all fluctuation as meaningful	Control chart with centre line and limits

B. Bar Charts, Dot Plots and Pie Charts

Bar charts are effective for comparing counts, proportions or rates across categories when all bars use a common baseline. Horizontal layouts improve readability when labels are long, and ordering categories by value can make patterns easier to see. Dot plots use less ink and can be especially effective when many categories must be compared.

Pie charts are familiar but rely on angle and area judgments that are difficult when slices are similar or numerous. They may be acceptable for a small number of clearly different parts that sum to a meaningful whole, but they should not be used for precise comparison or repeated across groups. Sorted bars or dot plots are usually clearer.

C. Histograms, Density Plots and Box Plots

Histograms display the distribution of continuous data, but their appearance depends on bin width and starting point. Analysts should examine several sensible bin widths and avoid interpreting a shape created only by arbitrary grouping. Density plots provide a smooth representation but can conceal the actual sample size, while box plots efficiently compare groups but do not show multimodality or the number of observations unless supplemented.

Distribution graphics should be chosen with sample size in mind. For small samples, dot or strip plots can show every observation; for large samples, histograms, violin plots or density displays may be more informative.

D. Line Charts and Time-Series Graphics

Line charts are appropriate when observations have a meaningful order, especially time. The horizontal scale should reflect actual intervals, and interrupted series should show gaps rather than implying continuous observation. Annotations can identify policy changes, outbreaks or data-system disruptions, but they should not obscure the underlying series.

Seasonality, population growth and changes in case definition can affect trends. Public-health line charts should therefore distinguish counts from rates and show denominators or population adjustments where relevant.

E. Scatter Plots and Relationship Graphics

Scatter plots display the joint distribution of two numerical variables. They can reveal linear or non-linear relationships, clusters, outliers and heteroscedasticity. Trend lines should be labelled as descriptive or model-based, and uncertainty bands should be included when inferential interpretation is intended.

Correlation should not be presented as causation. Apparent relationships may be produced by confounding, restricted ranges or aggregation. Stratified plots, colour-coded groups or small multiples can help identify whether a relationship is consistent across subgroups.

F. Showing Uncertainty

Graphs that show estimates without uncertainty encourage false precision. Confidence intervals, credible intervals, prediction intervals and sample sizes help readers distinguish a stable pattern from random variation. Error bars must be defined because standard deviations, standard errors and confidence intervals have different meanings.

Uncertainty should also be shown in maps and dashboards. Small-area rates may fluctuate sharply when denominators are small, and visually dramatic differences may not be statistically or practically meaningful.

G. Visual Integrity Audit

Table 2. Visual-integrity audit for statistical graphs

Audit domain	Key question	Warning sign	Corrective action
Chart selection	Does the graphic match the variable types and question?	Line chart used for unordered categories	Choose a chart based on comparison, distribution, time, relationship or composition
Scale	Does the axis represent magnitude honestly?	Truncated baseline exaggerates a small difference	Use a justified baseline and label any break clearly
Denominator	Are counts, percentages, rates and populations clearly distinguished?	Different groups use different hidden denominators	State numerator, denominator and unit in title or note
Uncertainty	Is precision or variation visible?	Point estimates appear exact	Add intervals, ranges, sample sizes or distribution
Colour	Does colour carry meaning and remain accessible?	Rainbow palette, low contrast or red-green dependence	Use limited, high-contrast and colour-blind-safe palettes
Labels	Can the graph be understood without guessing?	Missing units, unexplained abbreviations or unclear legend	Use direct labels, informative title and concise notes
Clutter	Does every element support interpretation?	3-D effects, gradients, heavy gridlines and decorative icons	Remove non-data ink and retain necessary context
Comparability	Are panels and groups shown on compatible scales?	Different axis limits create false differences	Use shared scales or clearly disclose exceptions
Missing data	Are gaps and exclusions visible?	Lines bridge periods with no observations	Show gaps, missingness or incomplete coverage
Reproducibility	Can the figure be recreated from data and code?	Manual editing changes values or labels	Save scripts, source data, metadata and export settings

IV. DISCUSSION AND APPLIED IMPLICATIONS

A. Graphs as Analytical Tools

Graphs should be used before, during and after formal analysis. Exploratory plots can reveal data errors, outliers, non-linearity and unequal variance before a model is fitted. Diagnostic plots can test whether model assumptions are reasonable, while final figures communicate results. Treating graphs only as decoration at the end of a study wastes much of their analytical value.

B. Communication With Technical and Non-Technical Audiences

Technical audiences may require detailed scales, intervals, model diagnostics and footnotes, whereas public audiences often benefit from a focused message, direct labels and plain-language explanation. Simplification should remove clutter, not evidence. Important qualifiers, denominators and uncertainty should remain visible.

C. Accessibility and Inclusive Design

Graphs should remain understandable for readers with colour-vision deficiencies, low vision or limited digital access. Meaning should not depend on colour alone. High contrast, readable fonts, direct labels, patterned lines and text alternatives improve accessibility. Interactive graphics should include keyboard navigation and a downloadable table or static version.

D. Ethics and Misleading Visualisation

Misleading graphics may result from error, convenience or deliberate persuasion. Ethical presentation requires truthful geometry, complete context and clear disclosure of transformations. Researchers should avoid selective time windows, hidden denominators, visually inflated effects and post hoc subgroup displays that exaggerate significance.

Reviewers and editors should assess visual integrity just as carefully as statistical methods. A graph can remain persuasive after readers forget the accompanying text, making ethical scrutiny especially important.

E. Public-Health Dashboards

Dashboards combine multiple indicators for rapid monitoring, but excessive panels and colour can overwhelm users. A useful dashboard begins with decisions: what action should be taken, by whom and at what threshold? Indicators should have clear definitions, update schedules, denominators and ownership.

Table 3. Decision-oriented framework for public-health dashboards

Dashboard element	Purpose	Minimum requirement	Common failure	Good practice
Headline indicator	Show current status	Definition, unit, period and target	Large number without context	Include comparison with target or prior period
Trend panel	Show direction and unusual change	Consistent time interval and denominator	Count interpreted as rate	Use rate, annotation and uncertainty where needed
Geographic panel	Locate disparity or risk	Appropriate denominator and stable geography	Raw counts mapped as risk	Use rates and flag small populations
Equity panel	Show subgroup differences	Disaggregation by relevant social variables	National average hides inequality	Display gaps and sample sizes
Data quality panel	Show confidence in the dashboard	Completeness, timeliness and revisions	Poor data appear equally reliable	Use quality flags and update notes
Action panel	Connect evidence to response	Threshold, responsible team and next step	Dashboard informs but does not trigger action	State response protocol and review date

F. Software and Reproducibility

Excel, SPSS, Stata, R, Python and specialised visualisation tools can all produce valid graphs, but reproducibility is improved when figures are generated through saved scripts or documented workflows. Source data, transformations, labels, themes and export settings should be retained so that figures can be updated without manual reconstruction.

G. Limitations and Future Research

Graph effectiveness depends on task, audience and medium, so no single design rule applies universally. Future research should test visualisations with intended users, especially in multilingual and low-resource settings. More work is also needed on uncertainty communication, mobile-first dashboards, responsible artificial-intelligence-generated graphics and accessible interactive visualisation.

V. CONCLUSION AND RECOMMENDATIONS

Graphical presentation is a core method of statistical reasoning and scientific communication. Appropriate graphs reveal distributions, trends, relationships, comparisons and uncertainty; inappropriate graphs can exaggerate, hide or distort the same evidence. Quality therefore depends on matching the graph to the question and data, using honest scales, identifying denominators, displaying uncertainty and removing unnecessary decoration.

The most effective visualisations are not necessarily the most elaborate. They are the ones that help the intended audience make an accurate judgment with minimal confusion. Researchers, institutions and journals should treat graph design as part of methodological quality and research ethics.

Recommendations

i. Select graphs according to the analytical question and variable type rather than software defaults or familiarity.

ii. Use position and length on common scales for precise comparison and avoid unnecessary three-dimensional effects.

iii. State counts, denominators, units, time periods and data sources clearly.

iv. Show uncertainty, sample size and missingness whenever they affect interpretation.

v. Use consistent and justified axes, especially across multiple panels or comparison groups.

vi. Apply accessible colour palettes, direct labels and text alternatives; never rely on colour alone.

vii. Use maps only with appropriate population denominators and caution for small-area instability.

viii. Design dashboards around decisions, thresholds and responsible actions rather than the number of available indicators.

ix. Generate figures through reproducible scripts or fully documented workflows.

x. Include a formal visual-integrity check in research supervision, peer review and journal production.

VI. DECLARATIONS

Ethics Approval and Consent to Participate

This methodological review used published literature and illustrative examples and did not involve direct participation by human subjects.

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Conflict of Interest

The author declares no conflict of interest.

Data Availability

No primary dataset was generated. All methodological evidence is available from the cited sources.

Author Contribution

Dr. Daniel A. Otwori conceptualised the manuscript, conducted the methodological synthesis, developed the graphical-quality framework and prepared the final paper.

AI and Digital Tool Disclosure

Digital tools were used for language refinement, document formatting and reference organisation. The author reviewed the manuscript and accepts responsibility for its accuracy, interpretation and originality.

VII. REFERENCES

Agresti, A. (2013). Categorical data analysis (3rd ed.). Wiley.

Bluman, A. G. (2018). Elementary statistics: A step-by-step approach (10th ed.). McGraw-Hill Education.

Cairo, A. (2016). The truthful art: Data, charts, and maps for communication. New Riders.

Cleveland, W. S. (1993). Visualizing data. Hobart Press.

Few, S. (2012). Show me the numbers: Designing tables and graphs to enlighten (2nd ed.). Analytics Press.

Field, A. (2018). Discovering statistics using IBM SPSS Statistics (5th ed.). Sage.

Knaflic, C. N. (2015). Storytelling with data: A data visualization guide for business professionals. Wiley.

Mayer, R. E. (2009). Multimedia learning (2nd ed.). Cambridge University Press.

Moore, D. S., McCabe, G. P., & Craig, B. A. (2017). Introduction to the practice of statistics (9th ed.). W. H. Freeman.

Rothman, K. J., Greenland, S., & Lash, T. L. (2021). Modern epidemiology (4th ed.). Wolters Kluwer.

Tufte, E. R. (2001). The visual display of quantitative information (2nd ed.). Graphics Press.

Wilke, C. O. (2019). Fundamentals of data visualization. O'Reilly Media.

World Health Organization. (2017). Data quality review: A toolkit for facility data quality assessment. WHO.

World Health Organization. (2021). Guidance for health information system data quality and use. WHO.

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