Institute for Healthcare Improvement

Using Data for Improvement

Advanced Concepts

Monday, Oct 30 11:00- 12:30, 1:30-3:00

Room 212

Lloyd Provost, IHI and Associates in Process Improvement

Alison Starr, IHI Faculty

Using Data for Improvement – Advanced Concepts

Abstract:

Data provides the insights to develop improvement strategies, the energy to keep improvement efforts going, and the insights to evaluate the impact of the improvement work. But often data are not presented in a way to effectively communicate the improvement story. This workshop will explore approaches to bring your improvement data to life and use graphical methods to describe a successful improvement project and to present the story that you want to tell.

Objectives:

- Apply key methods of data visualization that are particularly useful for improvement initiatives.
- Describe the methods used to learn from data in improvement projects.
- Describe how Shewhart charts are a fundamental graphical method from the Science of Improvement.
- Recognize principles of graphical excellence and best practices to communicate clearly using data.
- Appreciate the difference in Improvement methods and traditional statistical inference methods.

He uses data as a drunken man uses lamp posts, for support rather than illumination

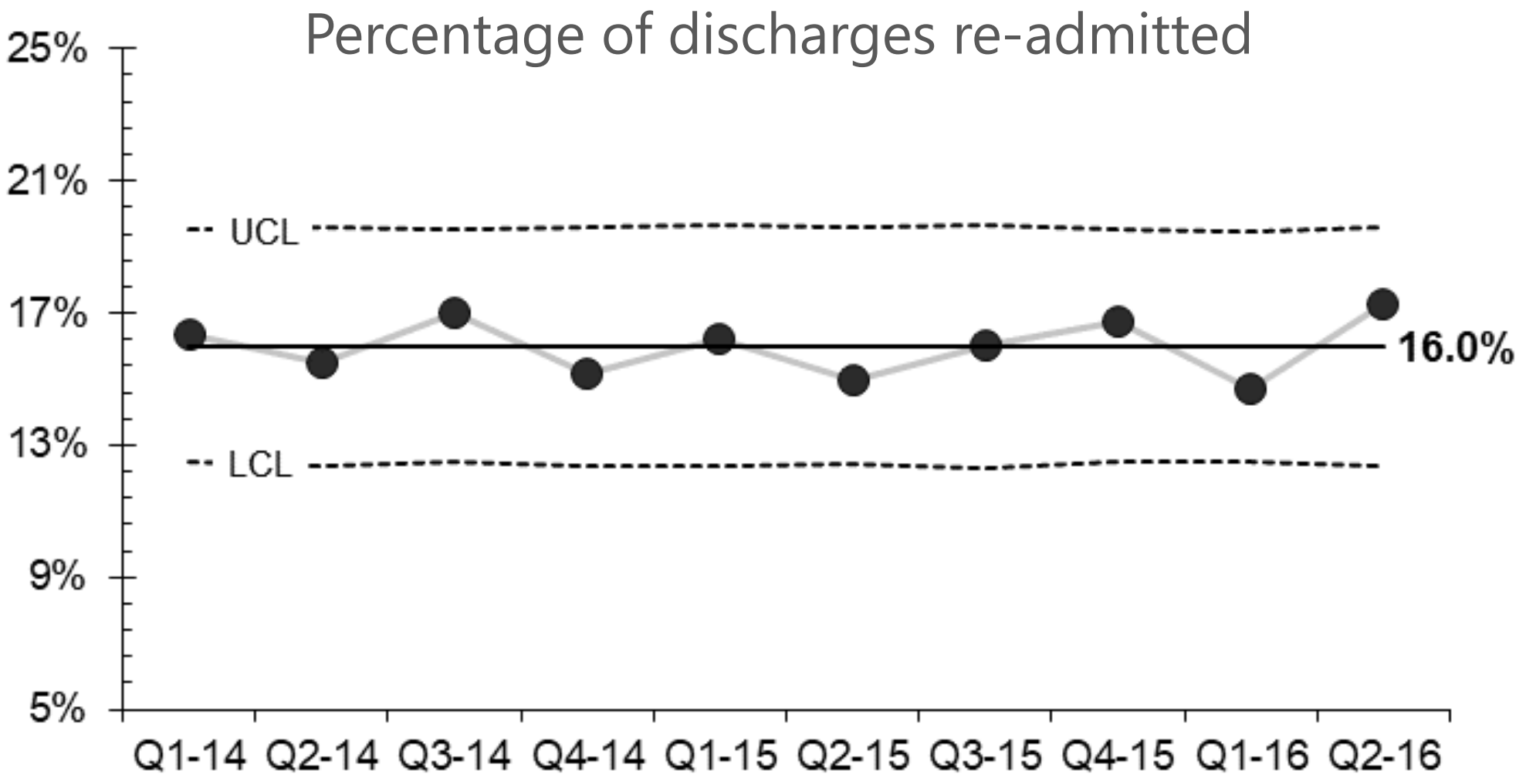
Andrew Lang, Scottish Writer

First: *Plot your Data*

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Measure Goal = 90%	83	80	81	84	83	85	68	87	89	92	91

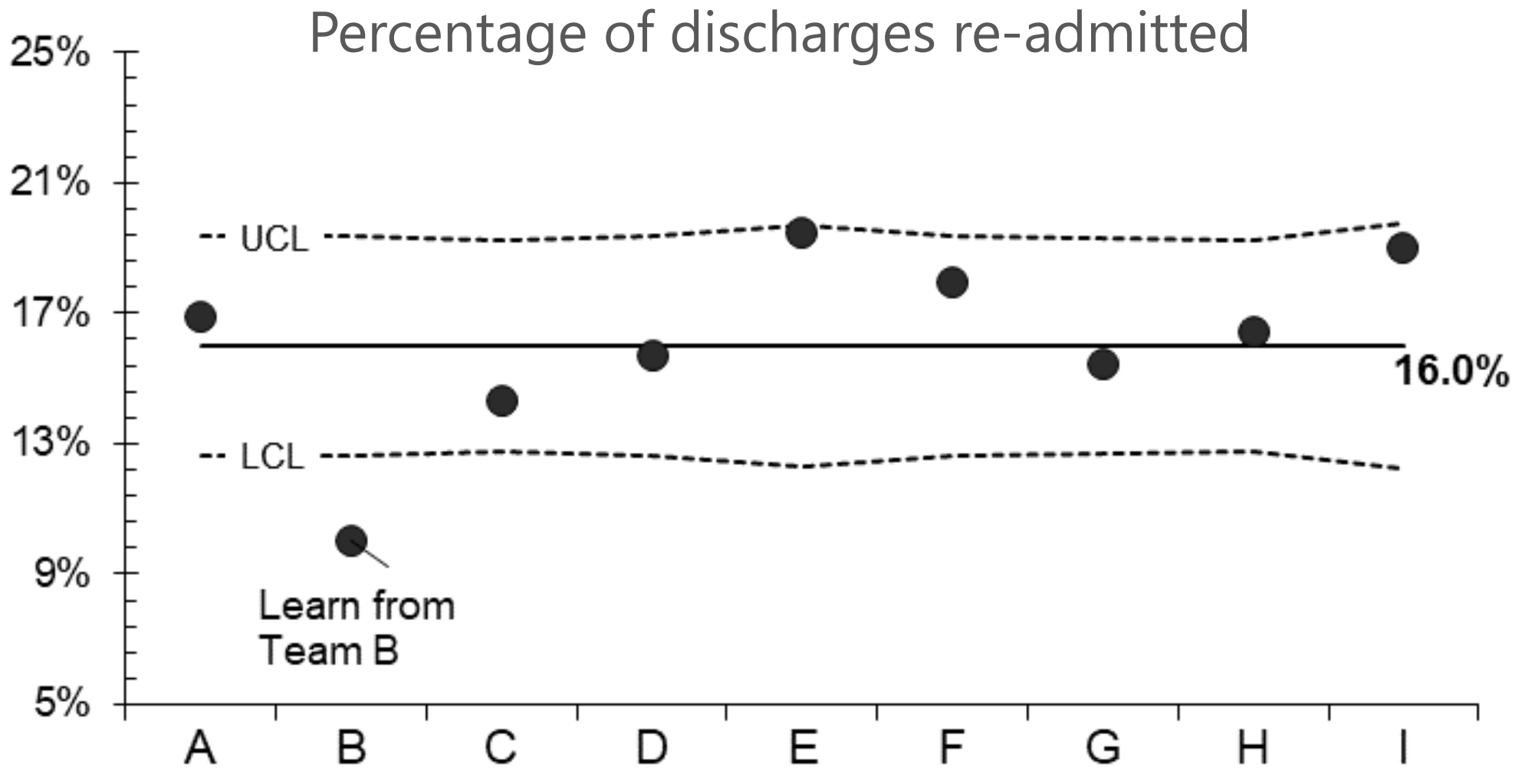
Data visualization for improvement often looks more like this *P*-chart:

$$\frac{\#\ readmitted}{\#\ discharged}$$



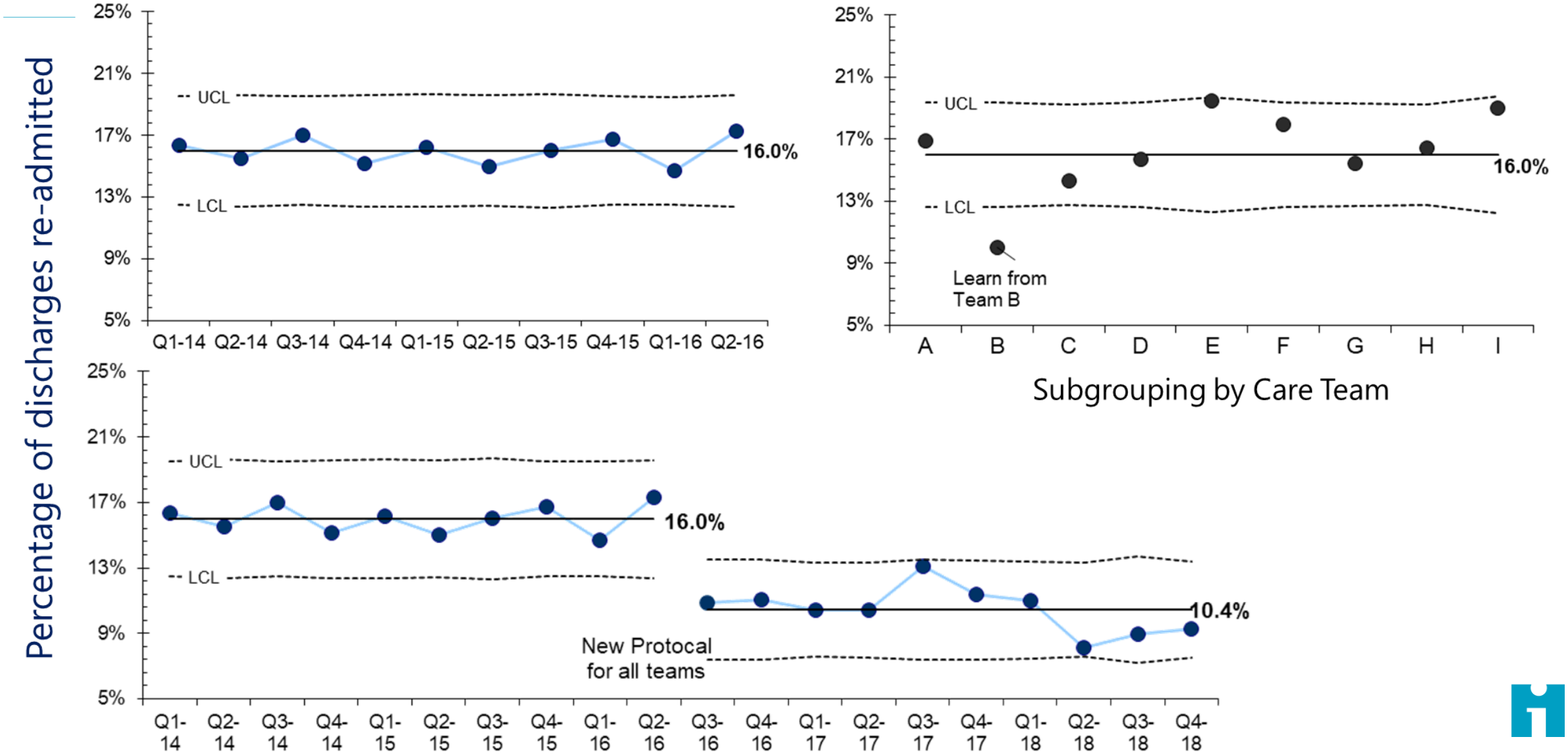
P-chart subgrouping by care team

$$\frac{\#\ readmitted}{\#\ discharged}$$



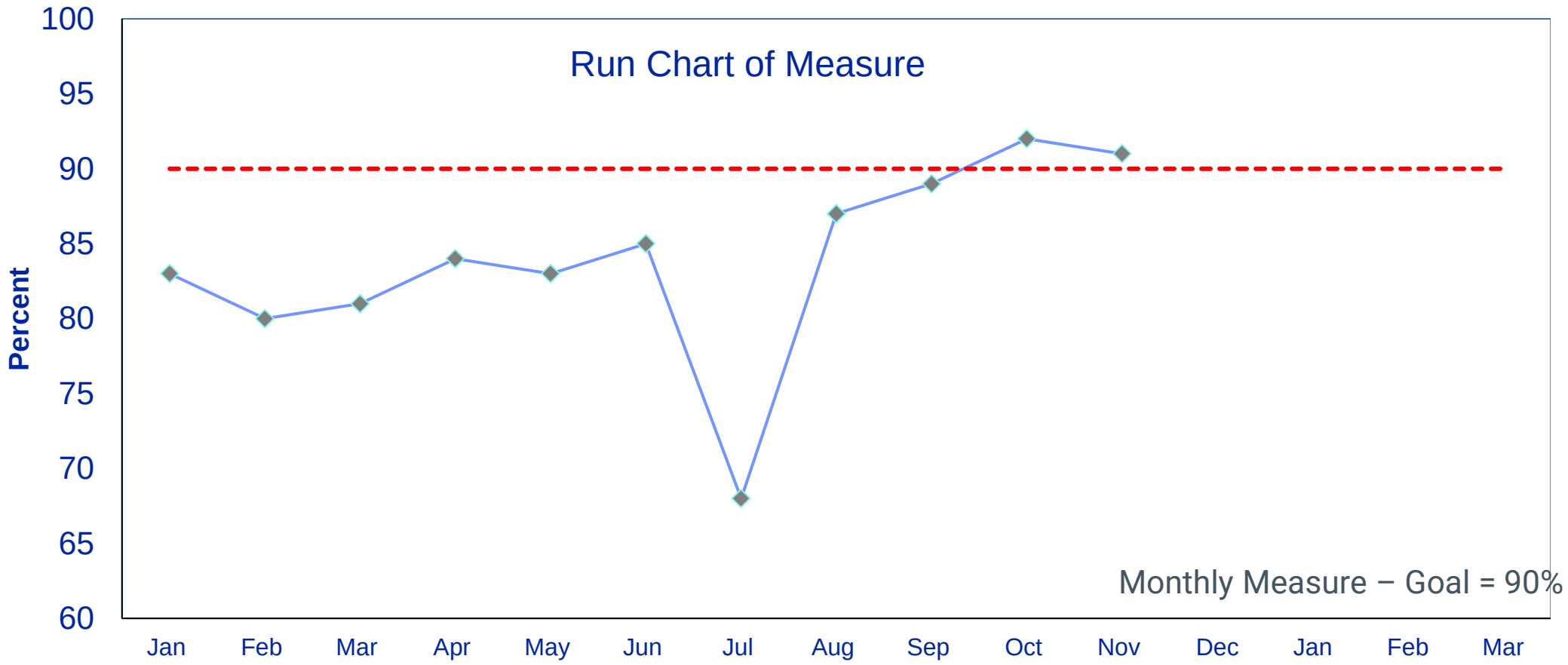
P-charts point to path for improvement

$$\frac{\#\ readmitted}{\#\ discharged}$$



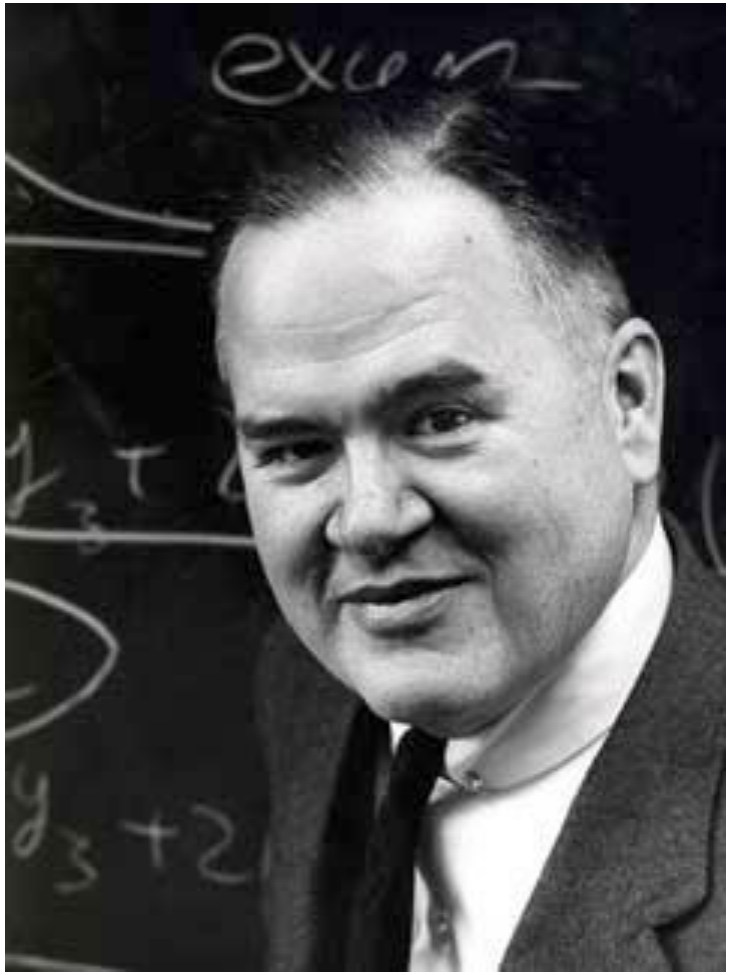
Second: *Annotate your Graph*

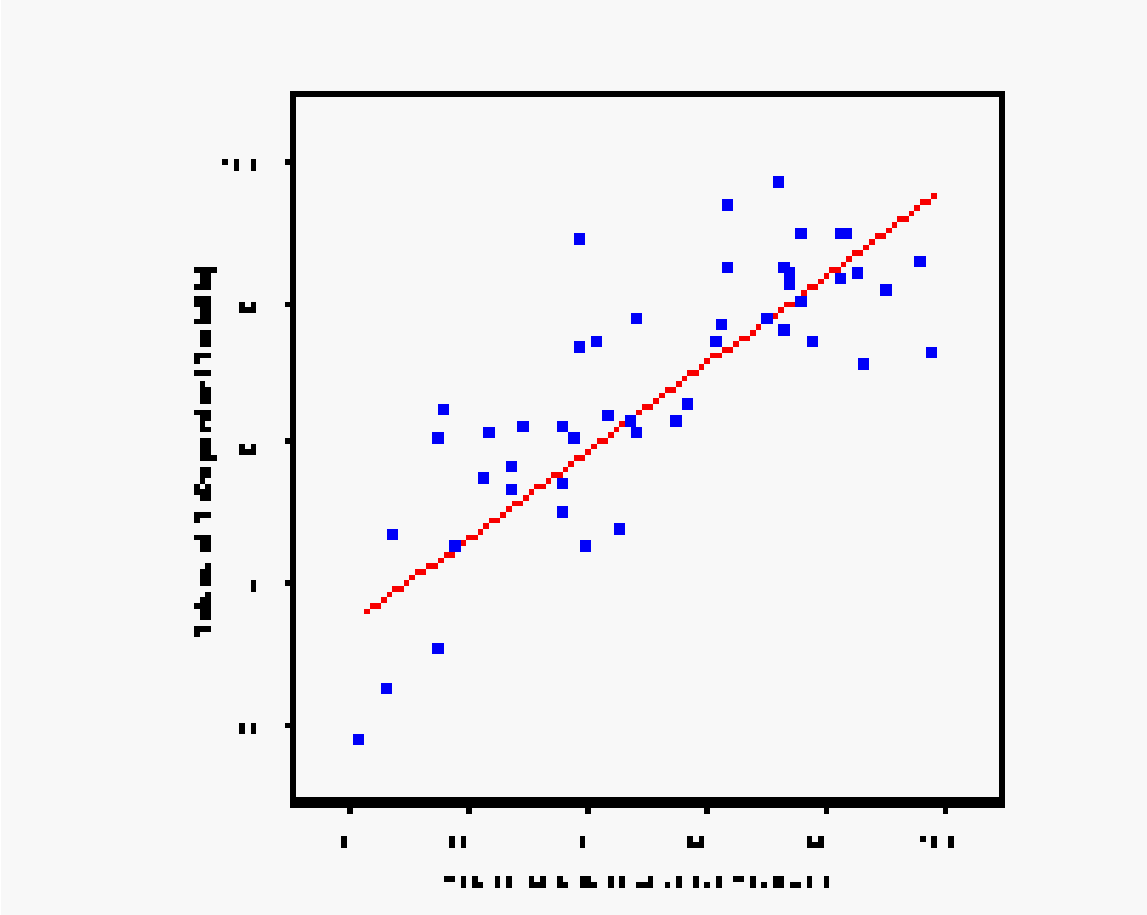
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Measure Goal = 90%	83	80	81	84	83	85	68	87	89	92	91



“The greatest value of a picture is when it forces us to notice what we never expected to see.”

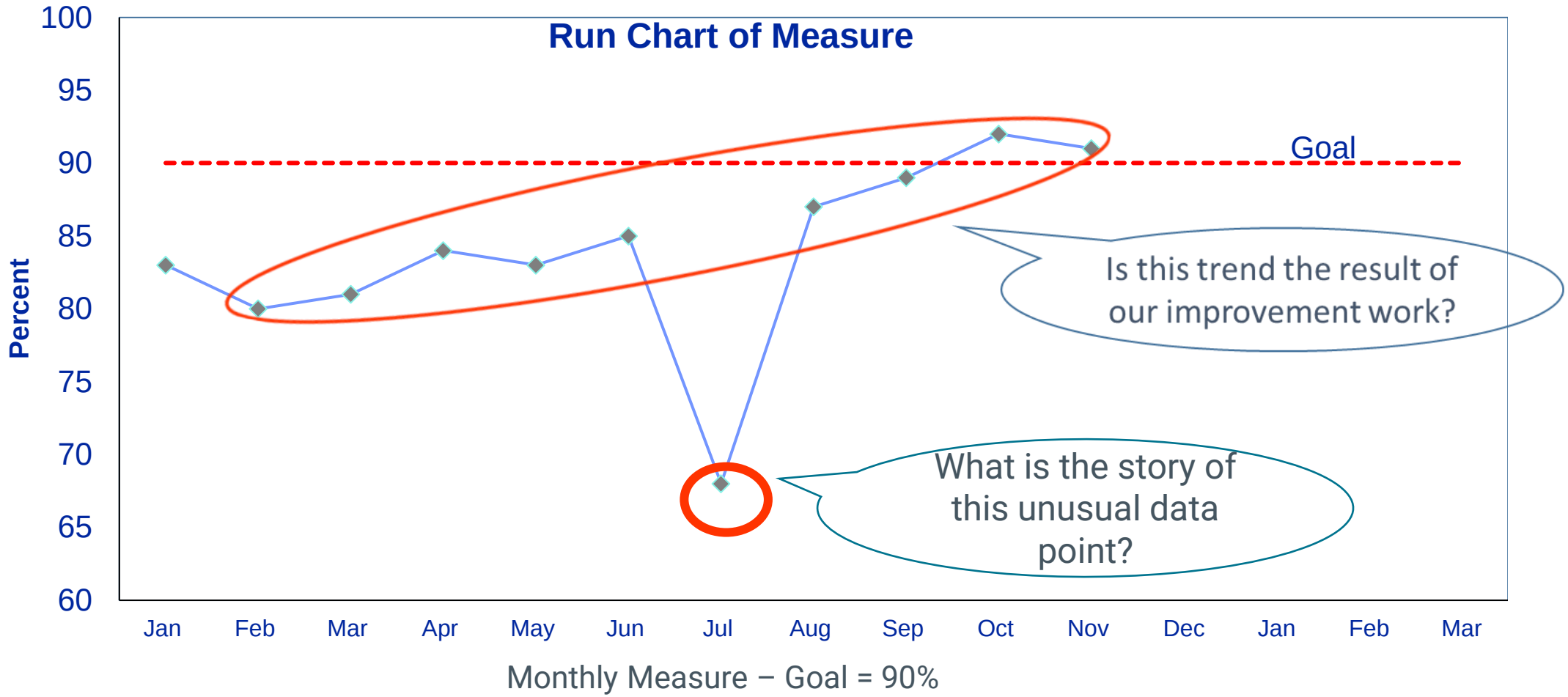
- John Tukey, 1977





Third: *Add Expression to tell a story*

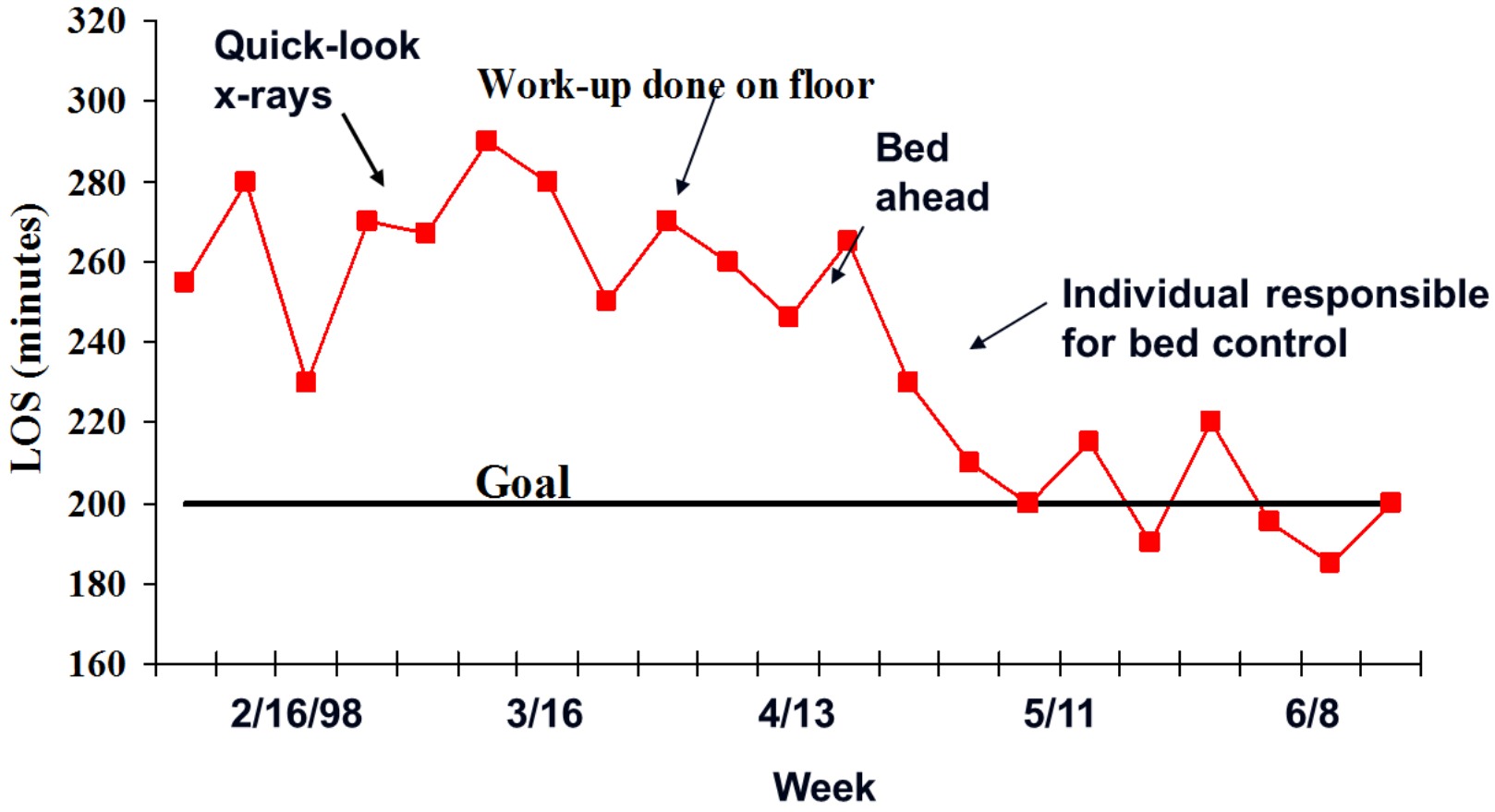
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Measure Goal = 90%	83	80	81	84	83	85	68	87	89	92	91



A graph should tell the story of your improvement project

Key Shewhart Principle for Presenting Data

"Whenever an average, range, or histogram is used to summarize data, the summary should not mislead the user into taking any action that the user would not take if the data were presented in a time series."



Why are charts and graphs among the most powerful tools that we have for learning from data and for improvement?

Record observations
Document a process
Explore root causes
Identify trends
Detect patterns
Test predictions
Support reasoning and decision-making
Convey ideas and information
Persuade, convince, or inspire others
Tell a story

The aim of the analysis is to give the experts in the subject matter the best possible chance to take the right action.

Descriptive Statistics

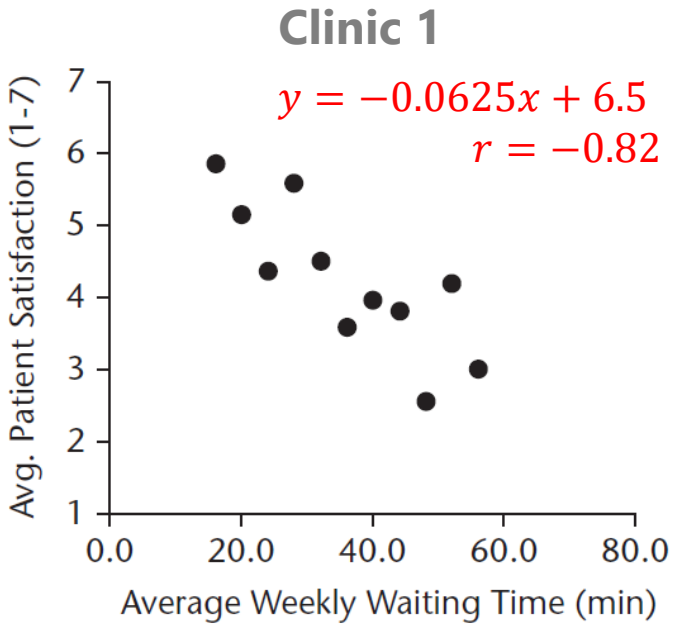
Table 4.1 Wait Time and Satisfaction Data from Four Clinics

	Clinic 1		Clinic 2		Clinic 3		Clinic 4	
Week	Average wait time (minutes)	Average patient rating	Average wait time (minutes)	Average patient rating	Average wait time (minutes)	Average patient rating	Average wait time (minutes)	Average patient rating
1	40.0	3.98	40.0	3.43	40.0	4.27	32.0	4.71
2	32.0	4.53	32.0	3.93	32.0	4.62	32.0	5.12
3	52.0	4.21	52.0	3.63	52.0	1.63	32.0	4.15
4	36.0	3.60	36.0	3.62	36.0	4.45	32.0	3.58
5	44.0	3.84	44.0	3.37	44.0	4.10	32.0	3.77
6	56.0	3.02	56.0	3.95	56.0	3.58	32.0	4.48
7	24.0	4.38	24.0	4.94	24.0	4.96	32.0	5.38
8	16.0	5.87	16.0	6.45	16.0	5.31	76.0	1.75
9	48.0	2.58	48.0	3.44	48.0	3.93	32.0	5.22
10	28.0	5.59	28.0	4.37	28.0	4.79	32.0	4.05
11	20.0	5.16	20.0	5.63	20.0	5.14	32.0	4.56
Number of weeks	11	11	11	11	11	11	11	11
Overall average	36.00	4.25	36.00	4.25	36.00	4.25	36.00	4.25
Standard deviation	13.27	1.02	13.27	1.02	13.27	1.02	13.27	1.02
Correlation: (r statistic)	0.82		0.82		0.82		0.82	
Regression: intercept/slope	6.50	–0.062	6.50	–0.062	6.50	–0.062	6.50	–0.062
Regression standard error	0.62		0.62		0.62		0.62	
P-value for regression	0.0022		0.0022		0.0022		0.0022	

Healthcare Data Guide, 2nd ed. Jossey Bass, 2022, adapted from:

Anscombe, F. J., "Graphs in Statistical Analysis," *American Statistician* 1973, *27*, 17–21.

Thinking of making decisions without first displaying the data?



> *...make **both** calculations **and** graphs. Both sorts of output should be studied; each will contribute to understanding.*
>
> *- F. J. Anscombe, 1973*

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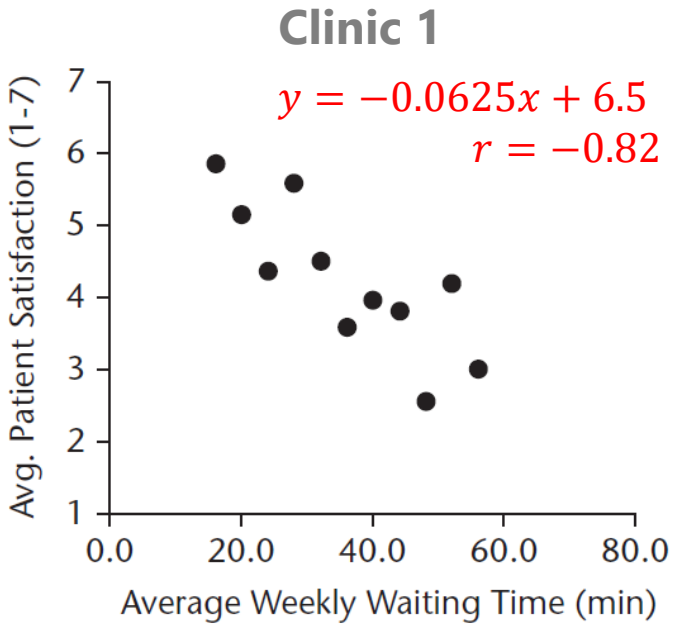

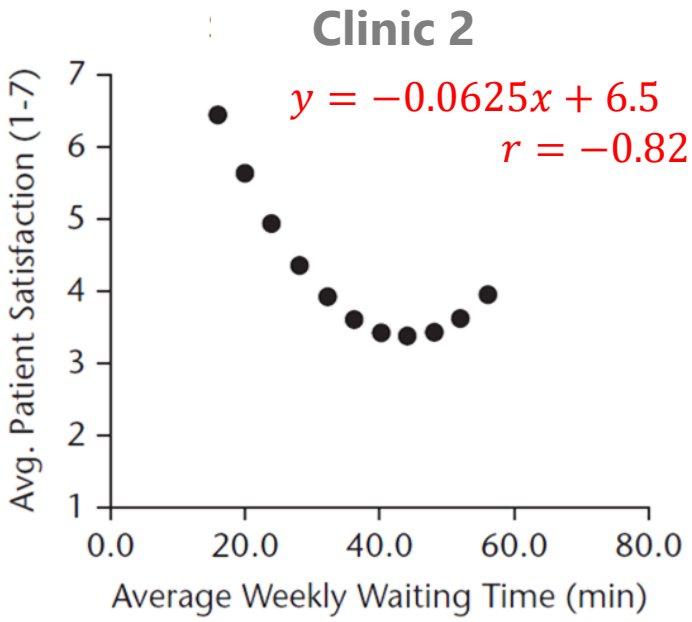

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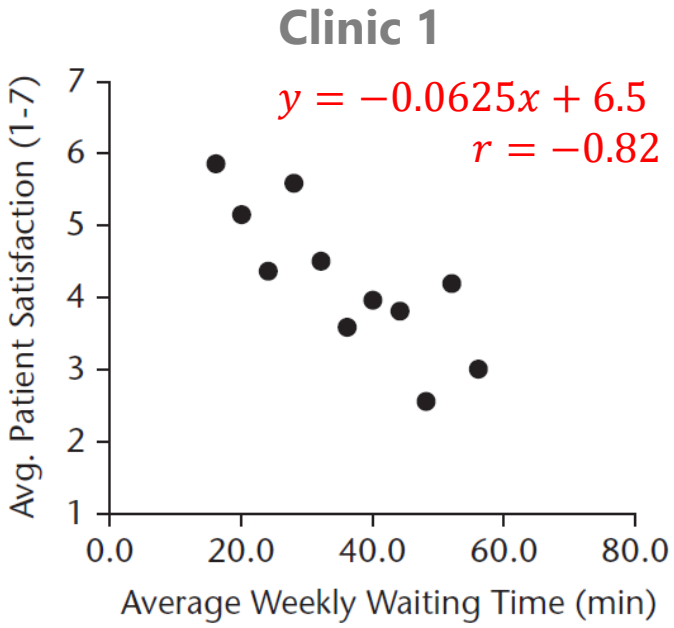

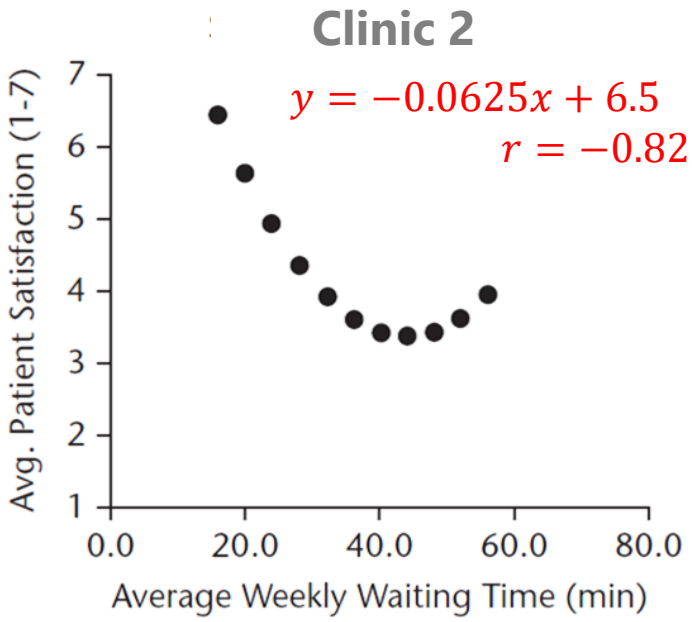

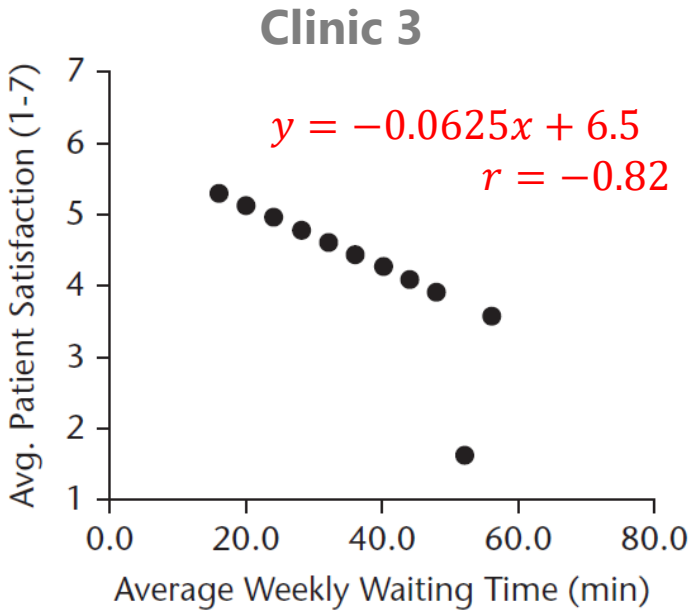

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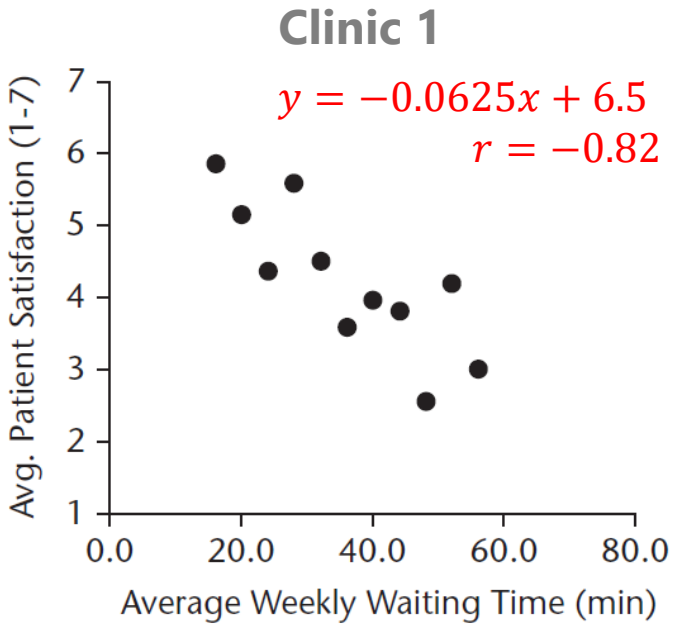

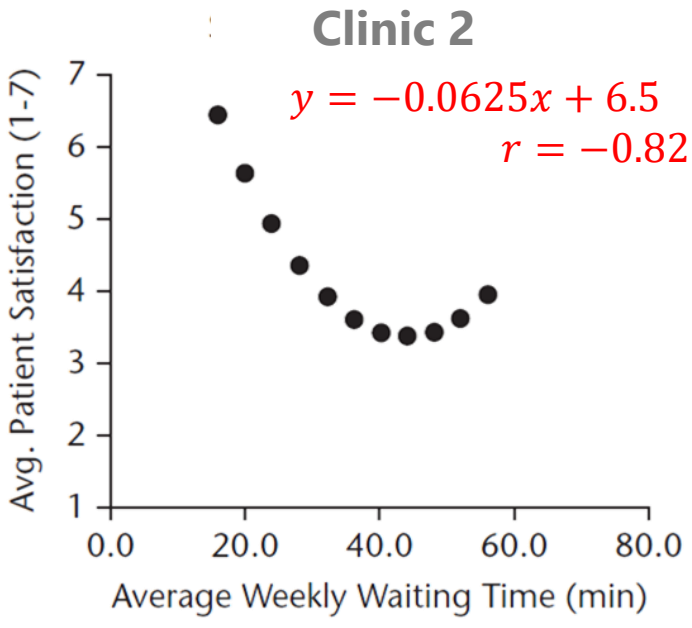

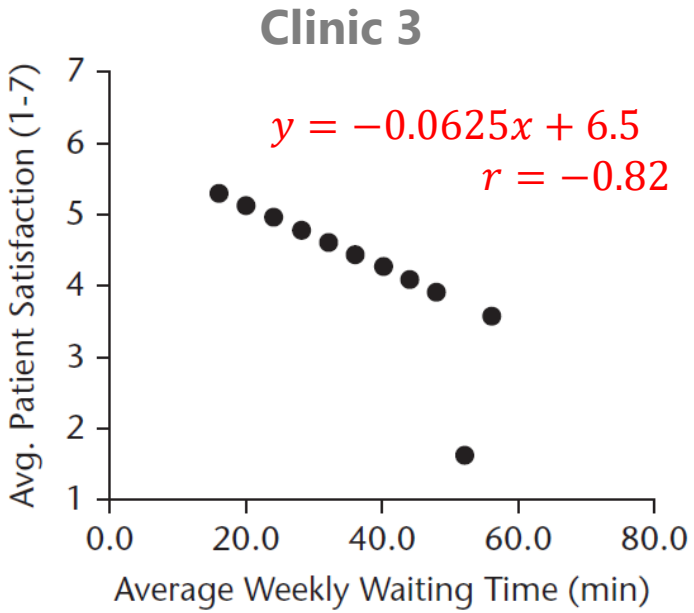

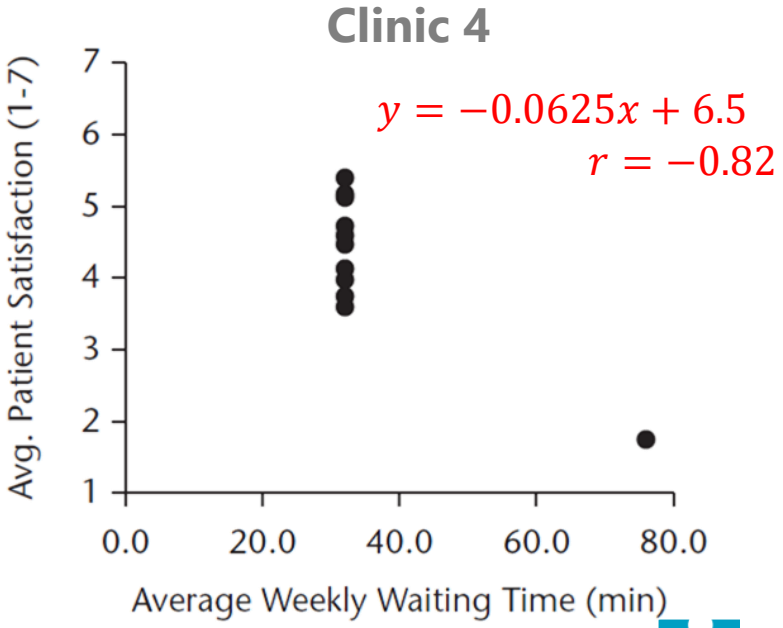

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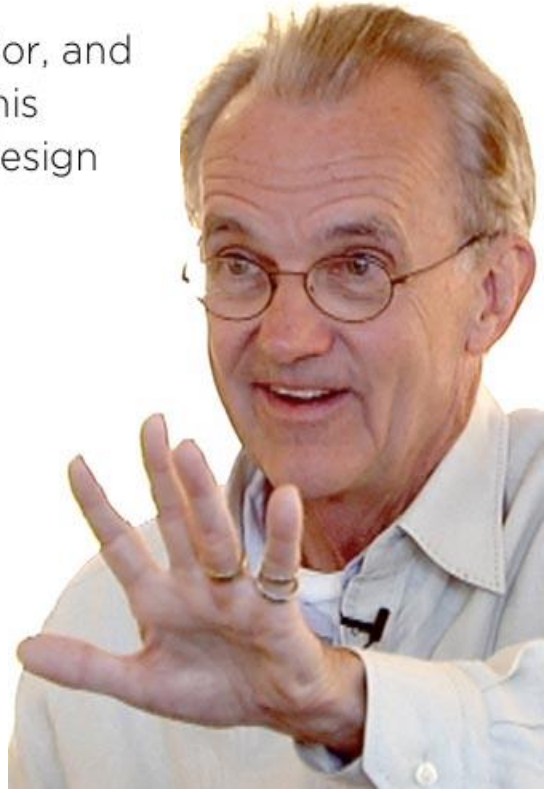
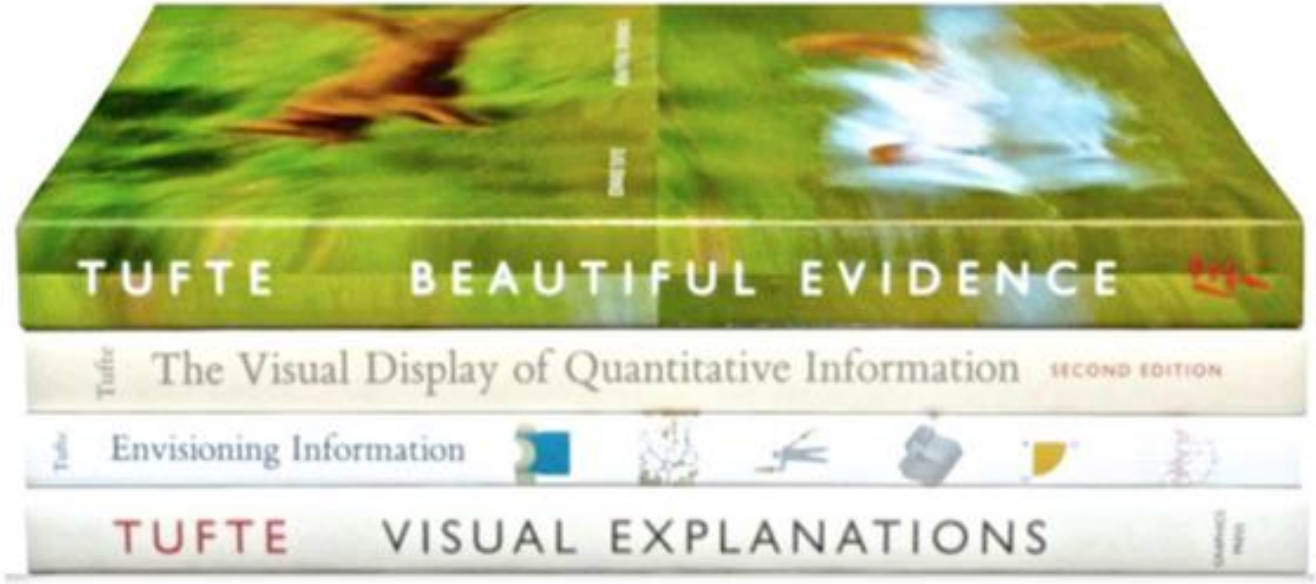
LESSONS FROM EDWARD TUFTE

an analytical design theorist, educator, and landscape sculptor best known for his self-published books on analytical design



Tufte believes that data should never be cheated. He has often remarked that if the audience notices the chart first and not the data then you have already failed.



"It is better to violate any design principle than to put graceless or inelegant marks on paper."

--Edward Tufte

Tufte's Graphical Excellence

Substance and integrity

Provide important information, never mislead by way we scale, sample, frequency

Statistics

Clarity and appropriateness of the statistic (percent, rate, mean, median, etc.)

Design principles

Use the least ink to present the greatest amount of information in the smallest space

> ***"It is better to violate any design principle than to put graceless or inelegant marks on paper."***
>
> --Edward Tufte

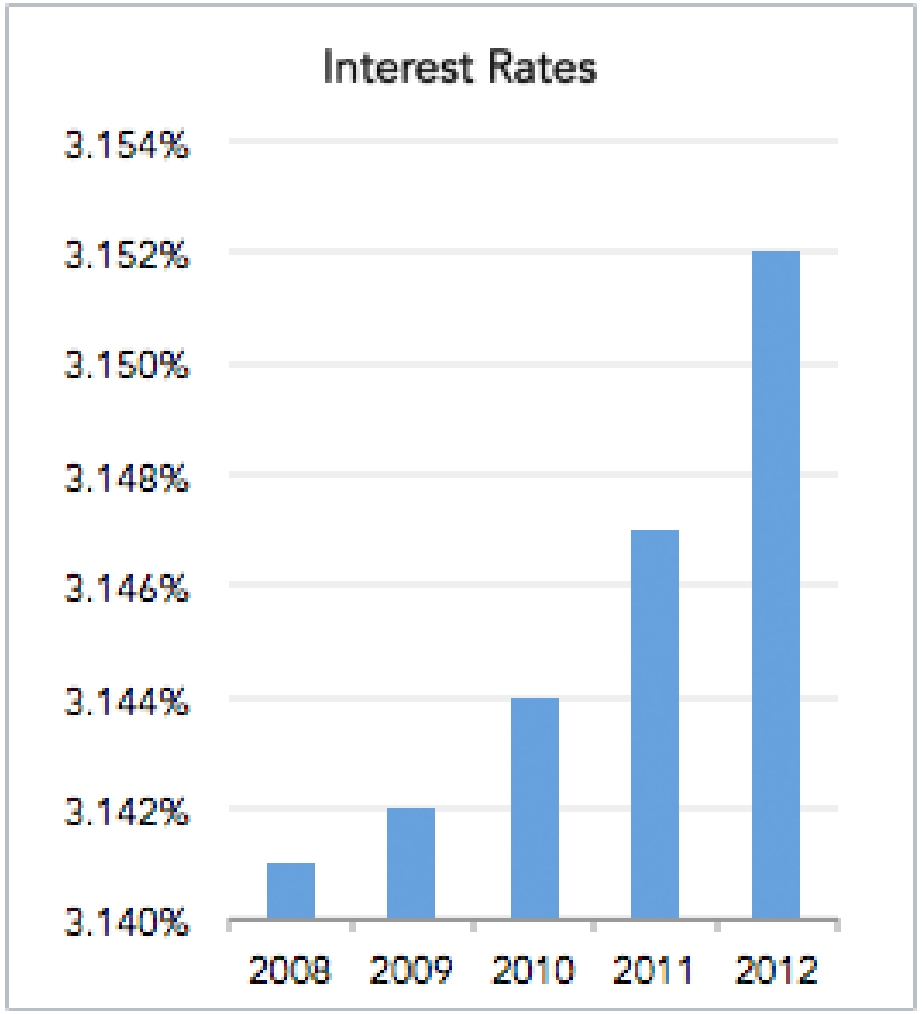
LESSONS FROM
EDWARD TUFTE

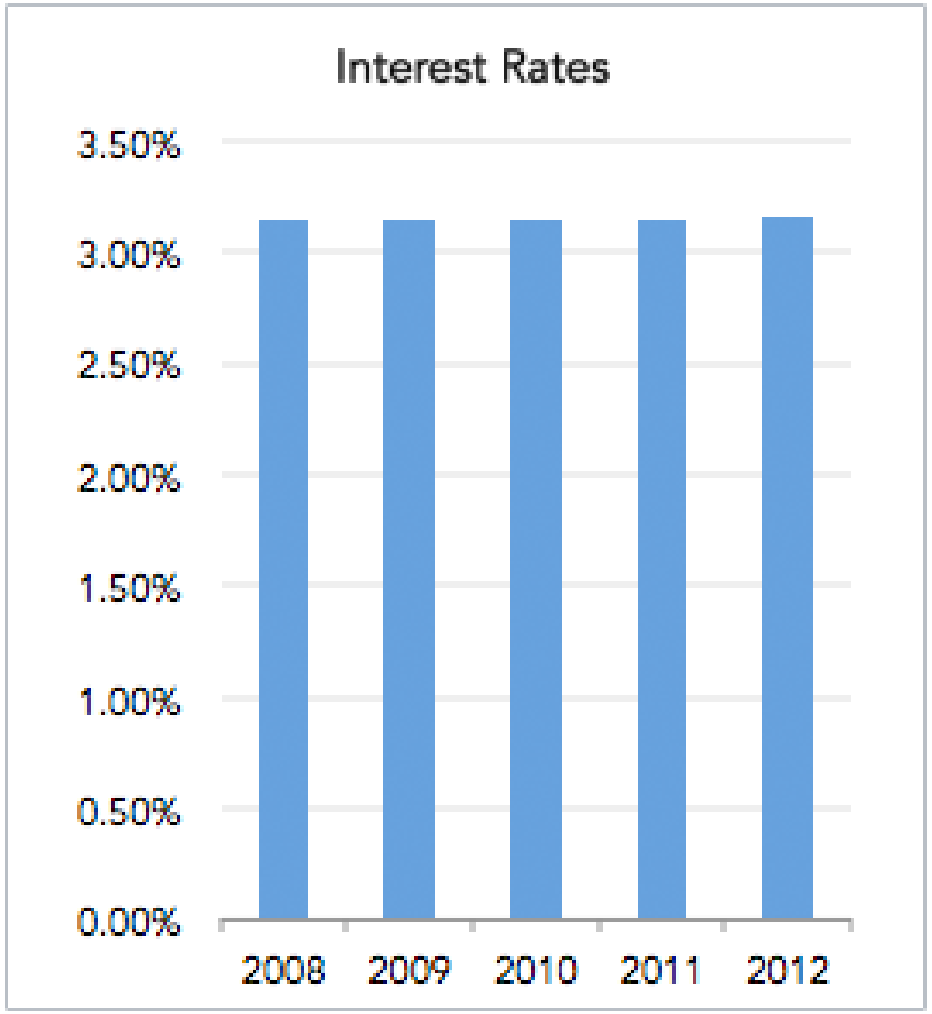
Substance and integrity

- ABOVE ALL ELSE: Show the data
- Provide important information, never mislead by way we scale, sample, frequency
- Allow for visual comparisons
- Integrate words, numbers, images, diagrams
- Minimize markings (uninformative ink) not directly related to the data
- Use the least ink to present the greatest amount of information in the smallest space

Misleading Graphics

Same Data, Different Y-Axis





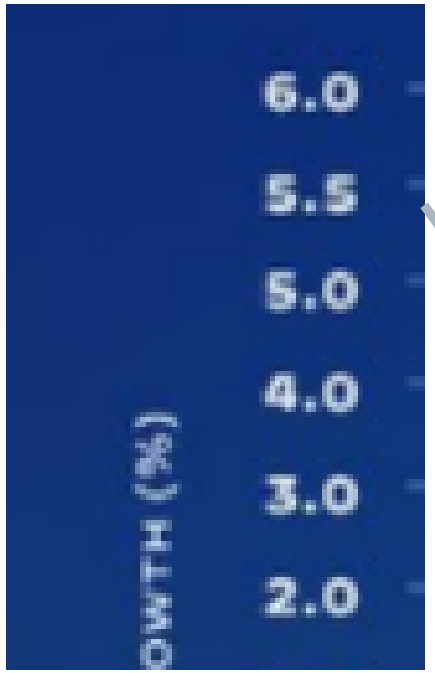
Scaling is very important

Bar Charts: typically start scale at 0 and continue past highest bar

Scatter Plot: square graph scaled to the data: no “white space”

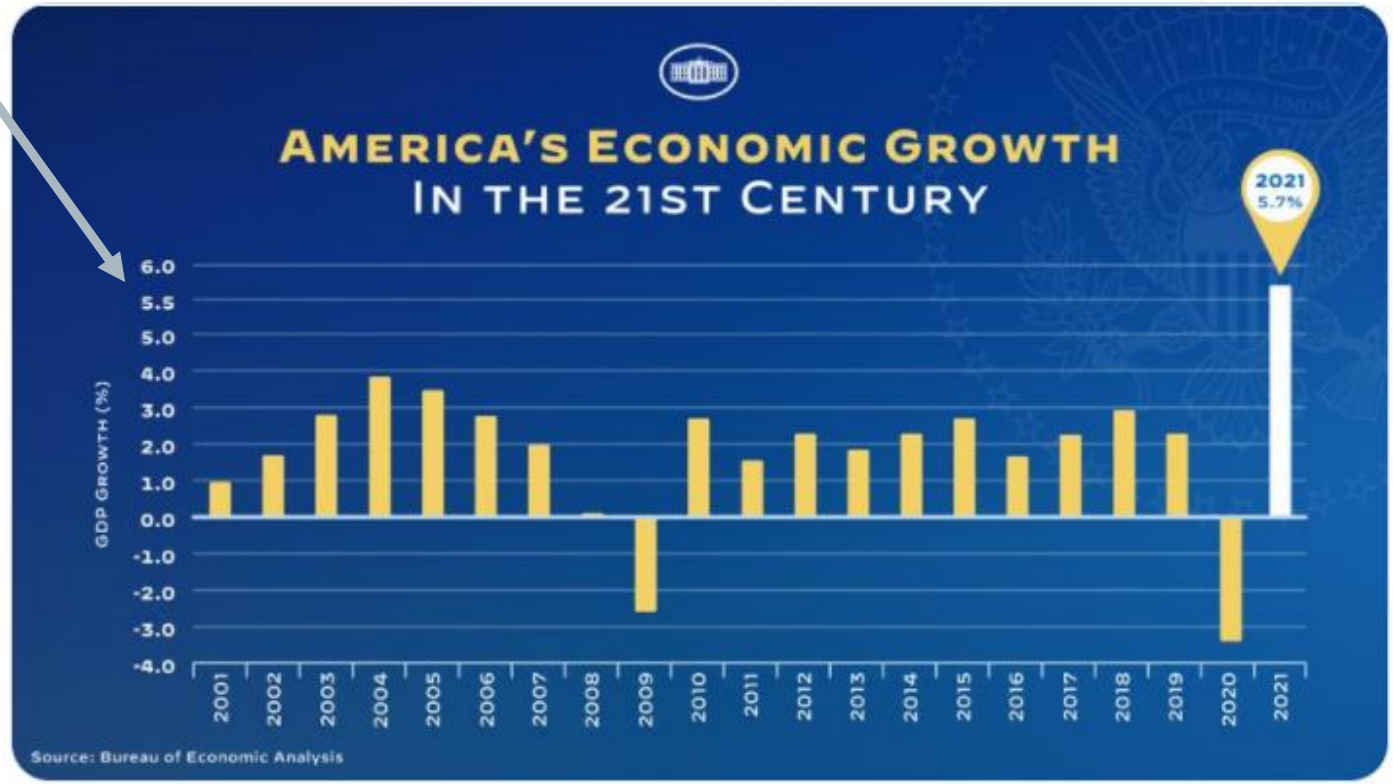
Run and Shewhart Charts:

- Scaled such that data uses about half of the graph’s scale with remaining 50% of scale as white space on either side of data
- If data cannot go beyond an absolute such as 0 or 100 then don’t extend the scale past these numbers



The White House
@WhiteHouse

We just learned that President Biden's first year in office was the strongest year for economic growth since 1984.



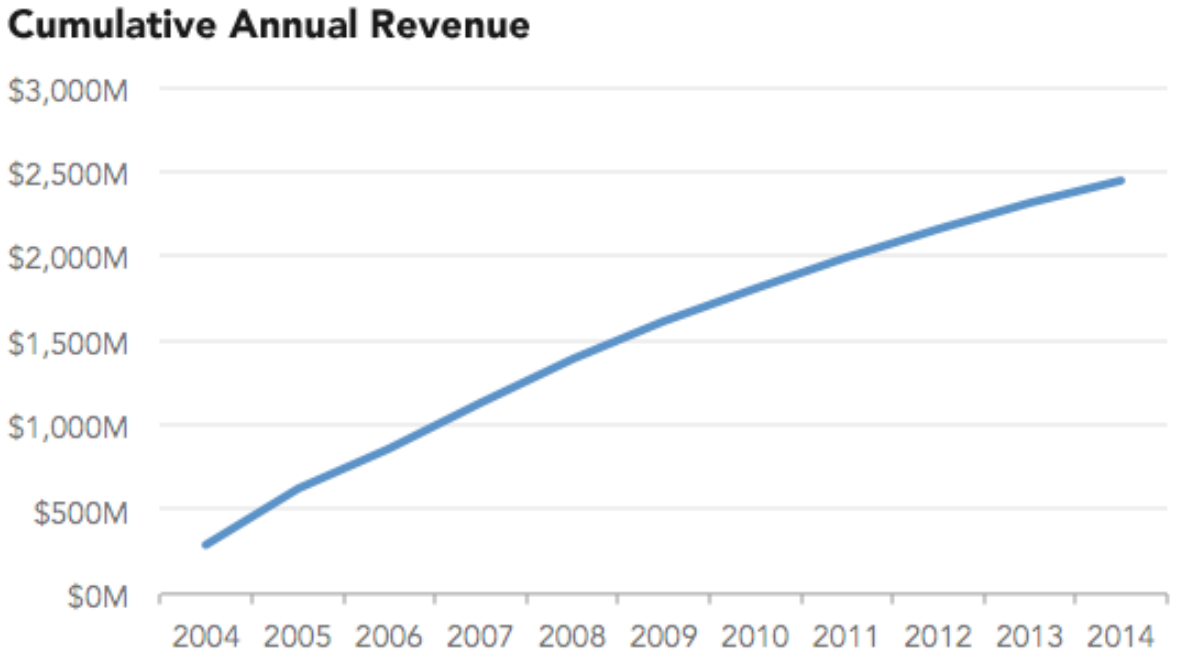
8:35 AM · Jan 27, 2022 · The White House

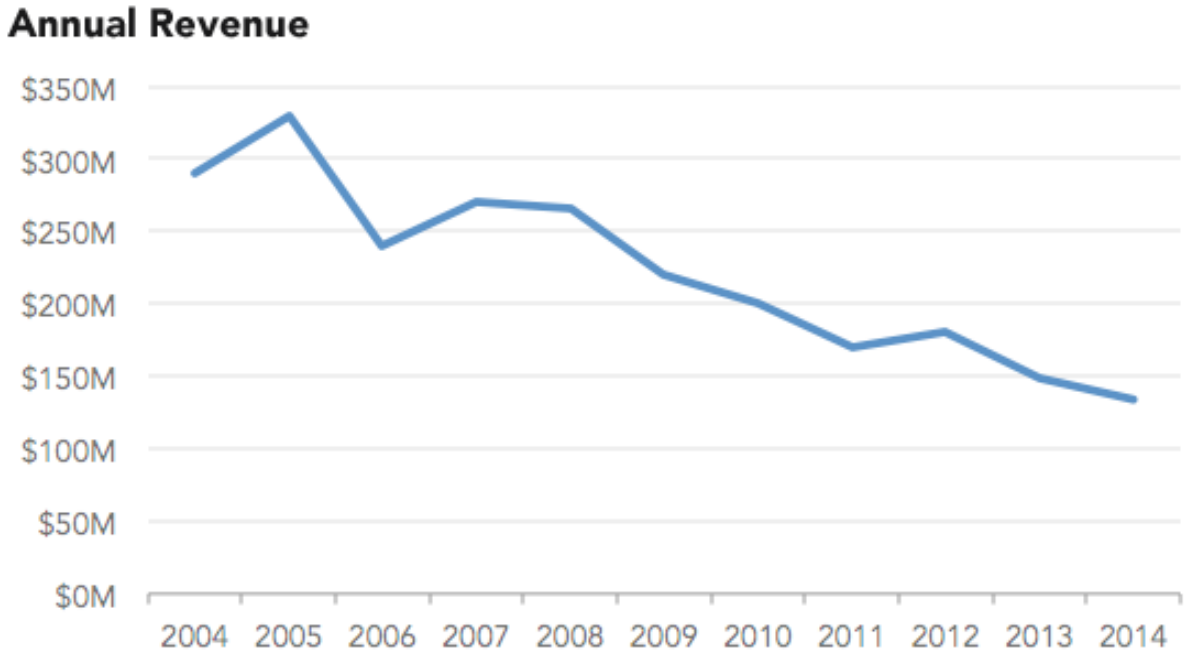
5,654 Retweets **2,637** Quote Tweets **20.2K** Likes

People on Twitter, in a break from standard behavior for the platform, mocked the tweet. And **in one of the less-predictable-by-the-Founding-Fathers examples of elected leaders hearing and responding to the electorate**, the White House admitted its error and corrected its graph.

Statistics

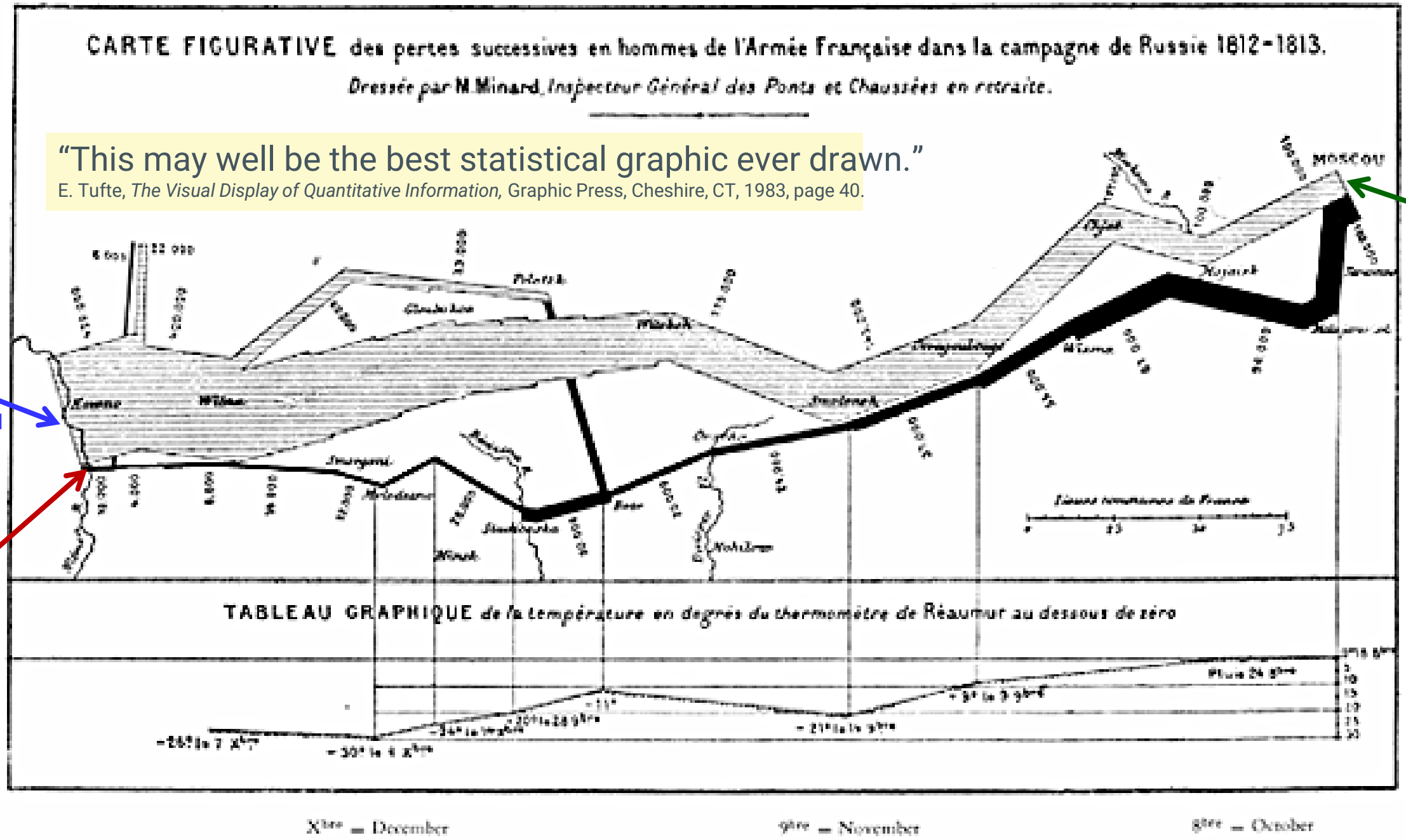
Clarity and appropriateness of the statistic (percent, rate, mean, median, etc.)





Graphical Principle:
Greatest amount of information in the smallest space

- Increase the information per unit of space
- Include multiple characteristics on the same graph or set of graphs
- Use small multiples - a series of charts, showing the same measure, but for different segments (location, departments, providers, and so on)
- Creation and use of dashboards of multiple charts, each chart displaying a different measure over the same time period



"This may well be the best statistical graphic ever drawn."
E. Tufte, *The Visual Display of Quantitative Information,* Graphic Press, Cheshire, CT, 1983, page 40.

422,000 men started the journey

10,000 men made it back to Poland

100,000 men arrived in Moscow

This graphic shows *six* variables simultaneously: the size of the army, its location on a two-dimensional surface, direction of the army's movement, and temperature on various dates during the retreat from Moscow.

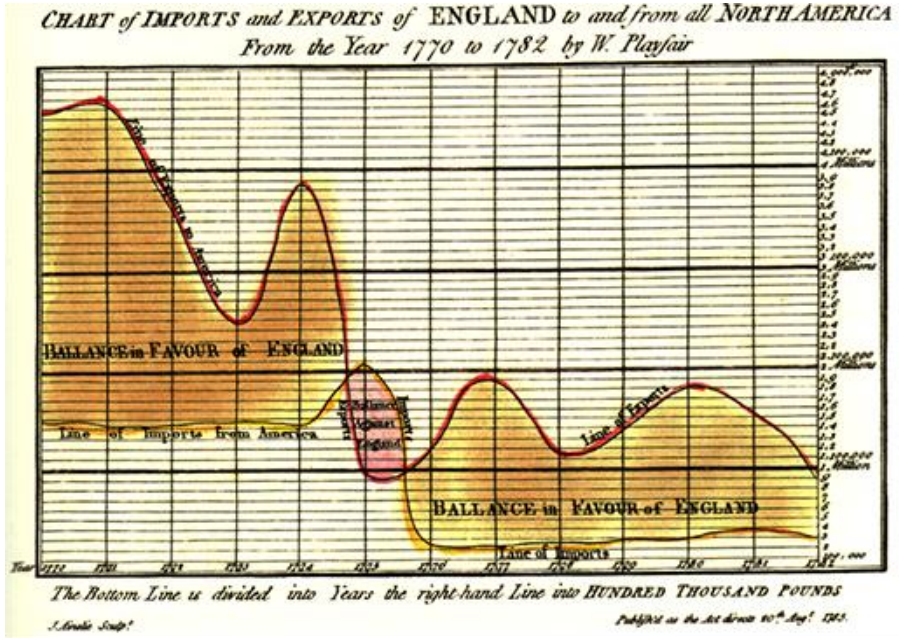
1 in 42

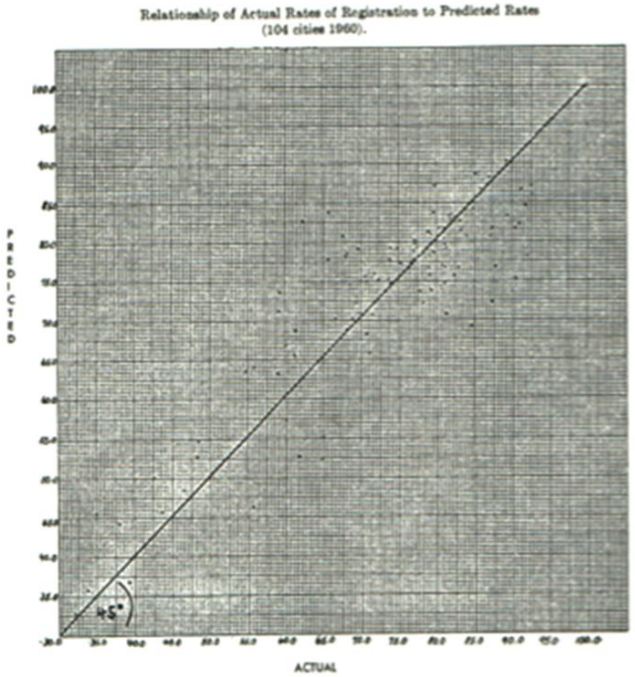
Grande Armée soldiers survived the Russian campaign of 1812

Painting by Adolph Northen (1828-76) / **Wiki Commons**

Design principle:

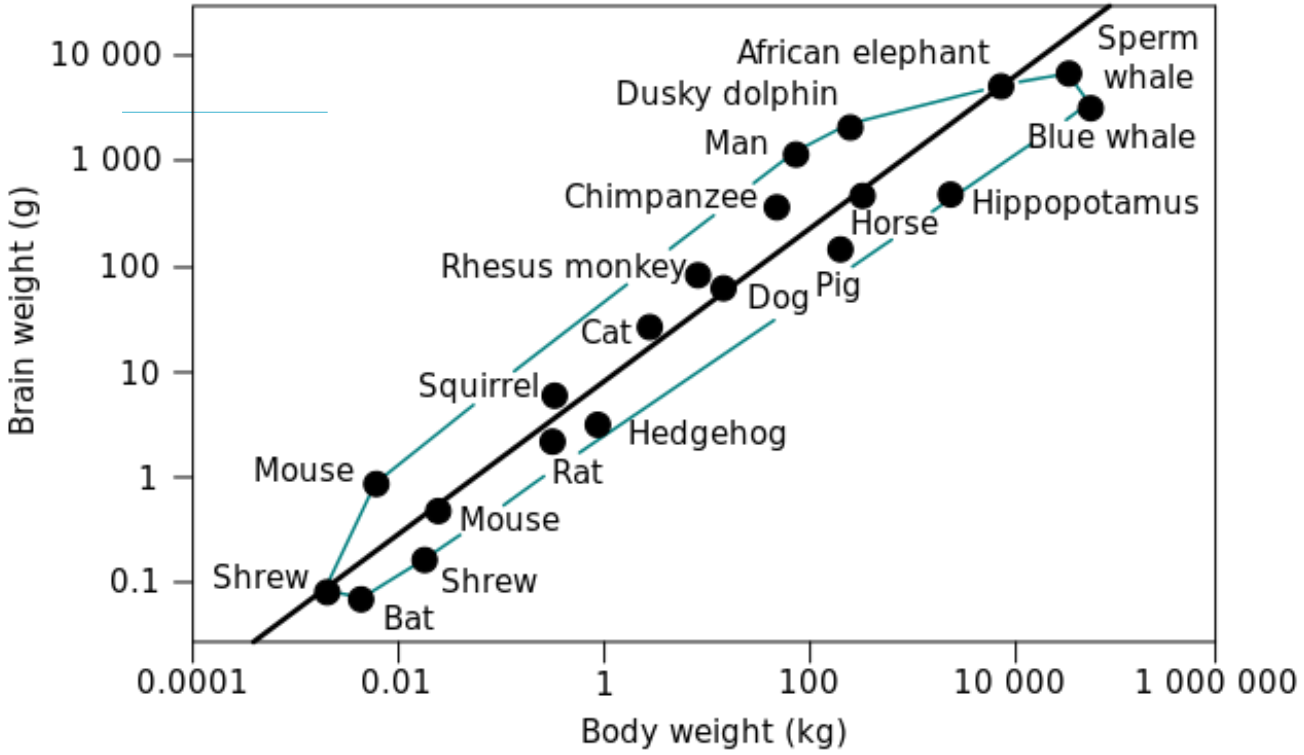
Use the least ink to present the greatest amount of information in the smallest space

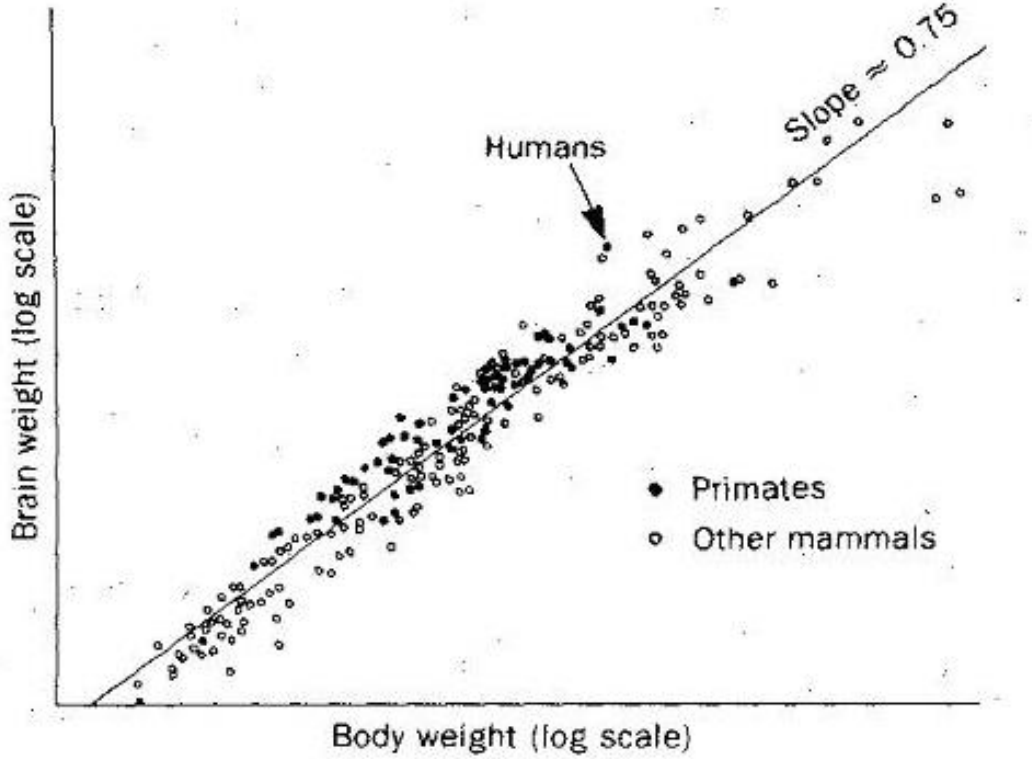




Minimize markings (uninformative ink) not directly related to the data

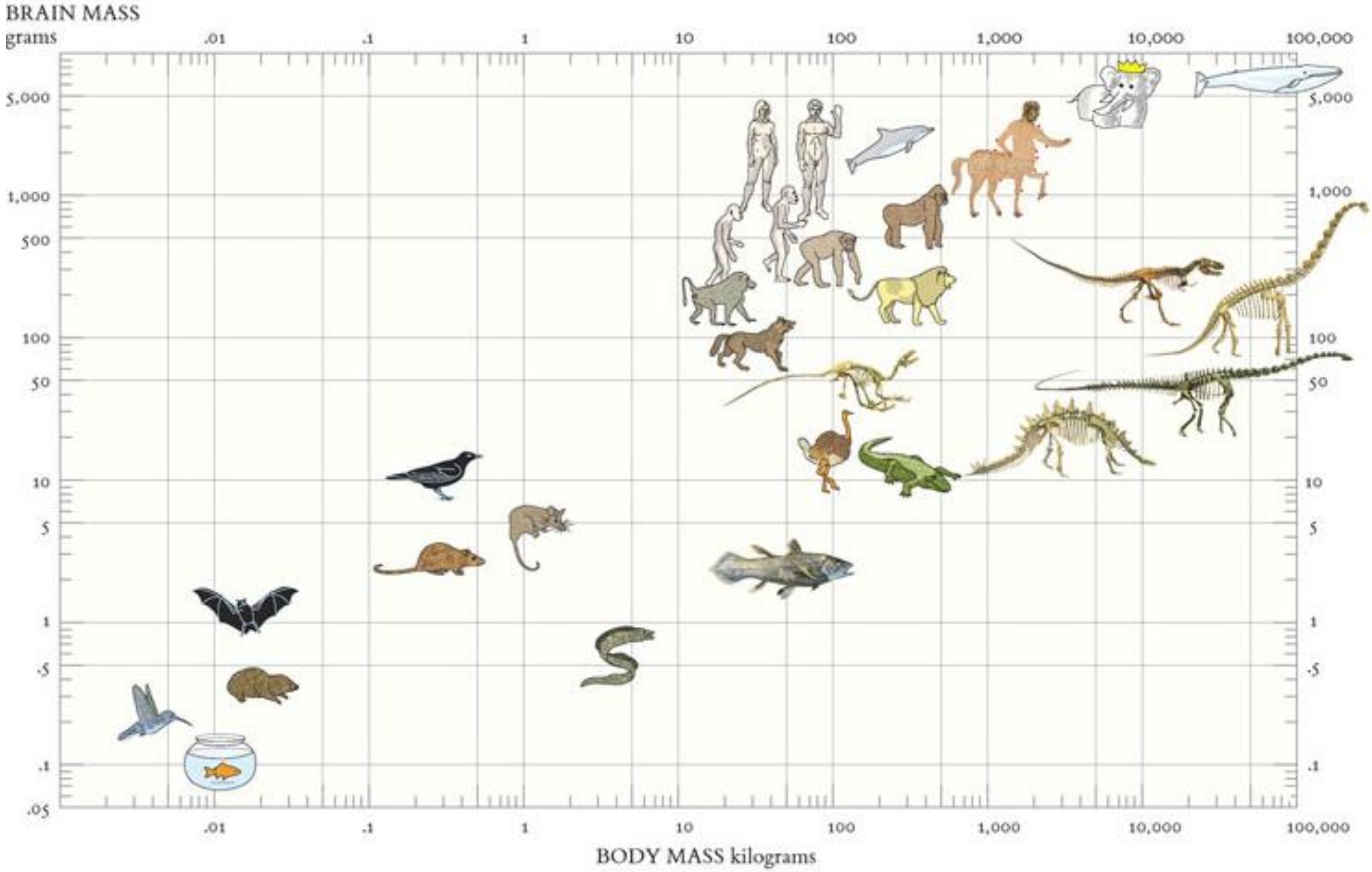
Communicating the Relationship between Brain Weight and Body Weight





Communicating the Relationship between Brain Weight and Body Weight

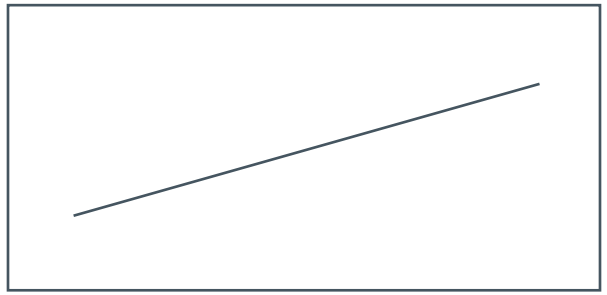
Integrate words, numbers, images, diagrams



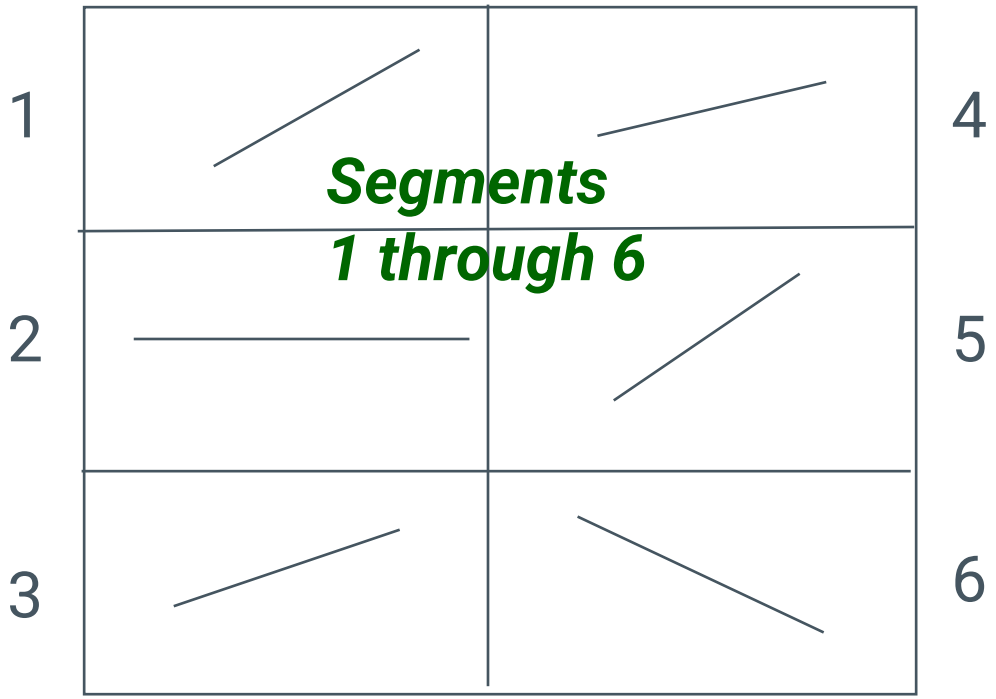
Small Multiples Layout

For small multiples each chart shows the same measure

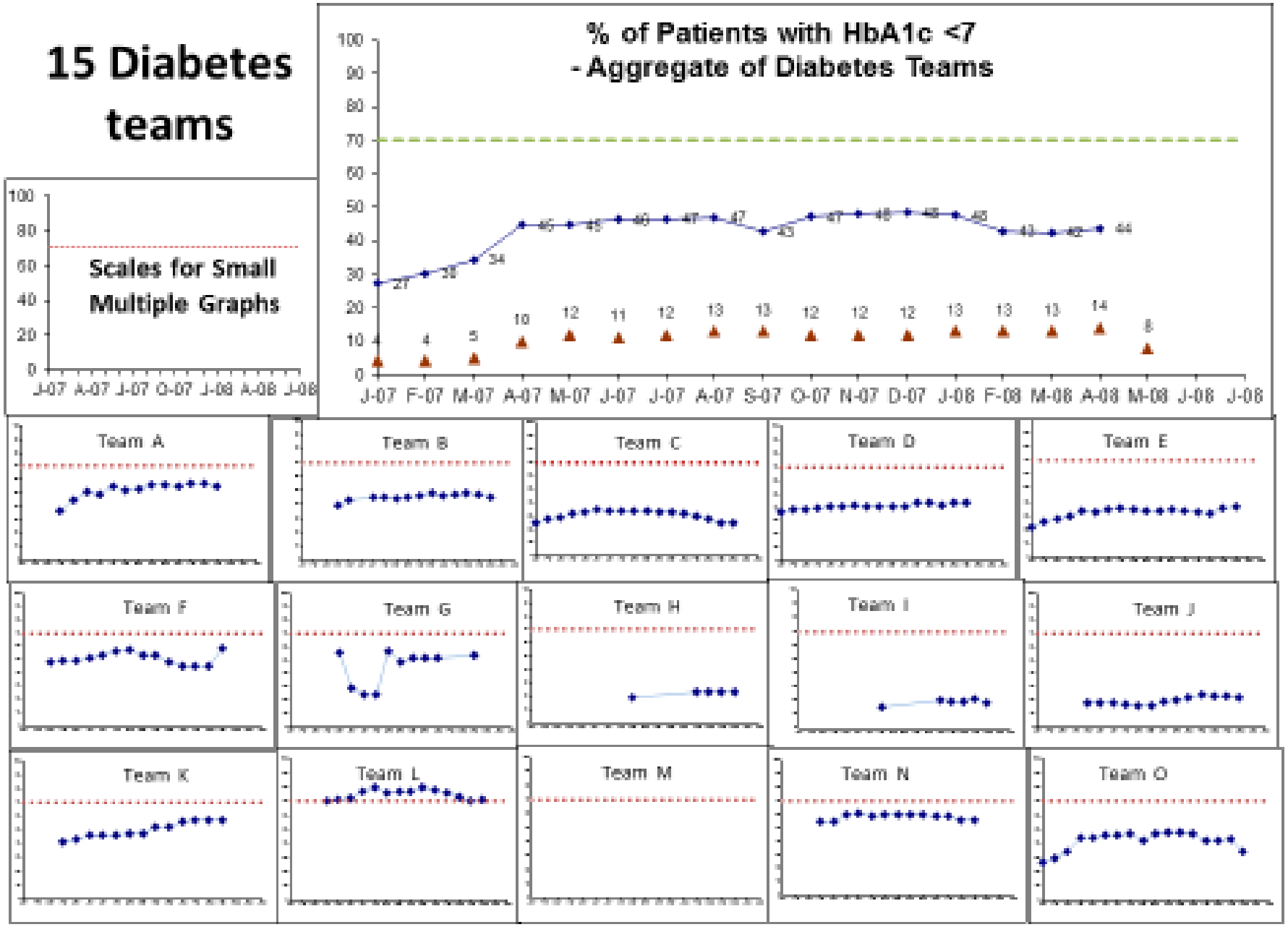
Overall



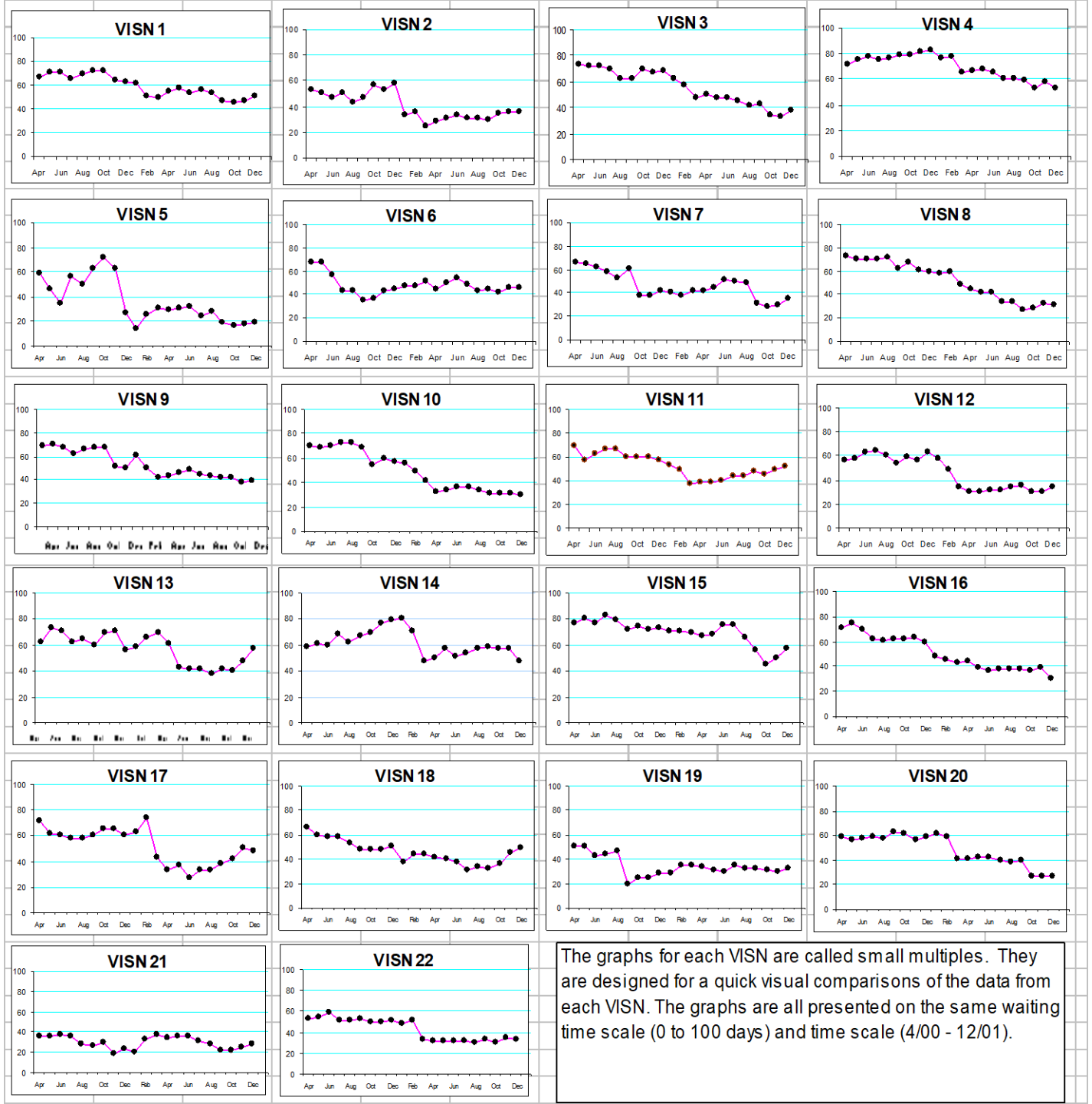
Note that for small multiples each chart should have the same scales (for both X and Y)



15 Diabetes teams



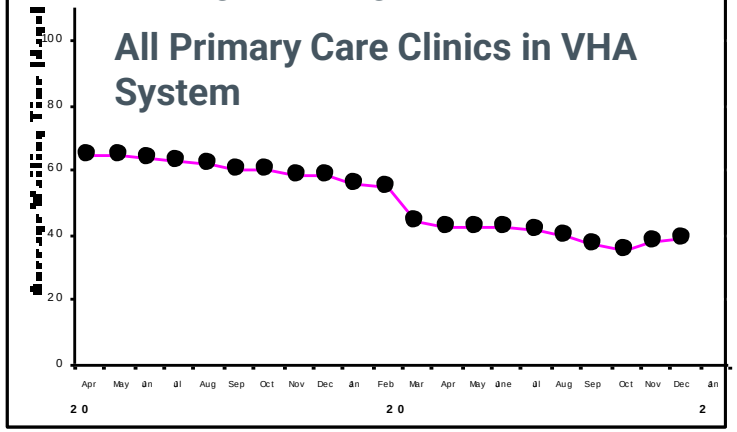
Small Multiples: Overall System and 22 Districts



The graphs for each VISN are called small multiples. They are designed for a quick visual comparisons of the data from each VISN. The graphs are all presented on the same waiting time scale (0 to 100 days) and time scale (4/00 - 12/01).

Average Waiting Times:

All Primary Care Clinics in VHA System



Things to Avoid When Graphing

Graphs should not:

- Distort what the data have to say.
- Mask important changes in the data.
- Rely on self-scaling of the Y axis.
- Change (scale or symbols, and so forth) in the middle of the graph.
- Use three-dimensional displays (unless the data are three-dimensional!).
- Use fancy art or borders to embellish the graphic.

An overriding principle…… “It is better to violate any design principle than to put graceless or inelegant marks on paper.” ….Edward Tufte

Exercise 2

Exercise: Chart Critique and Design

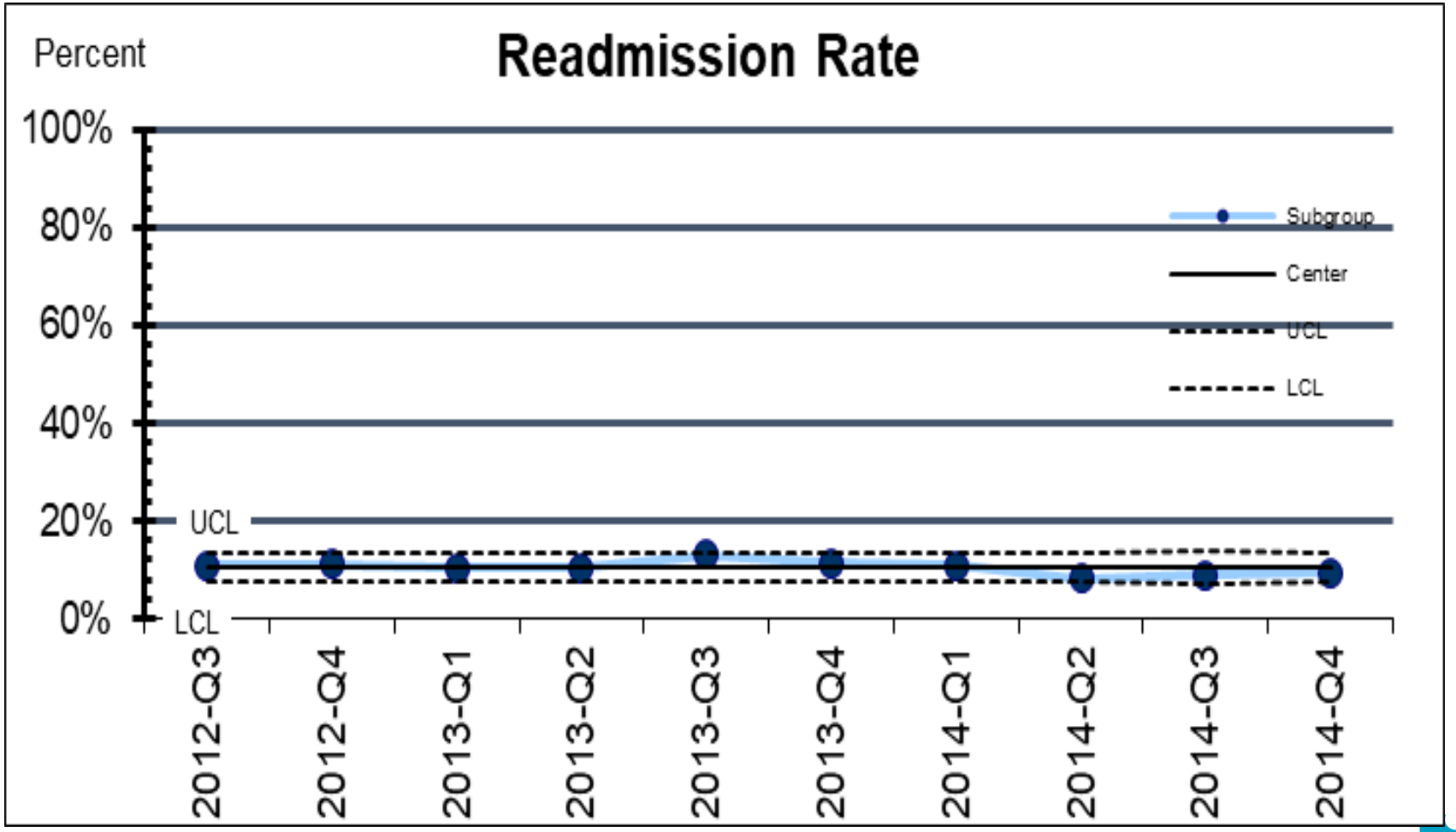
Apply your new insights about graphical excellence! We will share four charts that are in need of your suggestions for improvement.

Please record your ideas, comments, and questions as we show each chart for a few minutes.

Then share you thinking with your table.

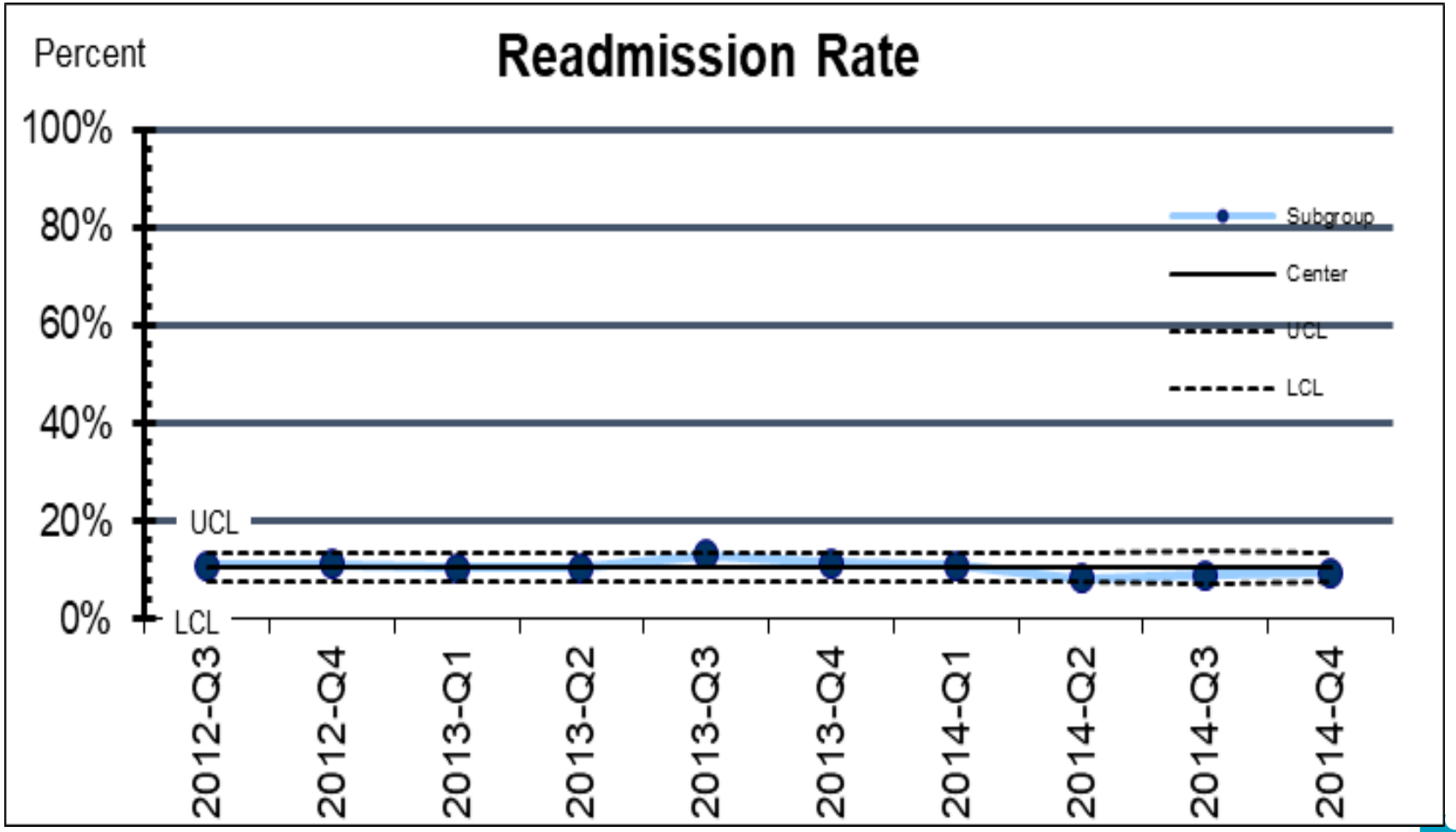
Together, sketch an improved version of the chart applying graphical excellence principles.

Apply your insights about graphical excellence to improve Chart #1

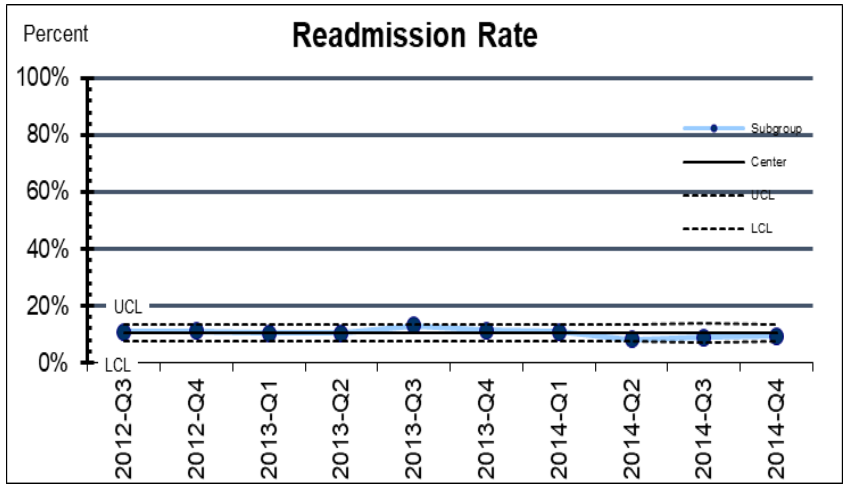


Apply your new insights about graphical excellence to improve this chart!

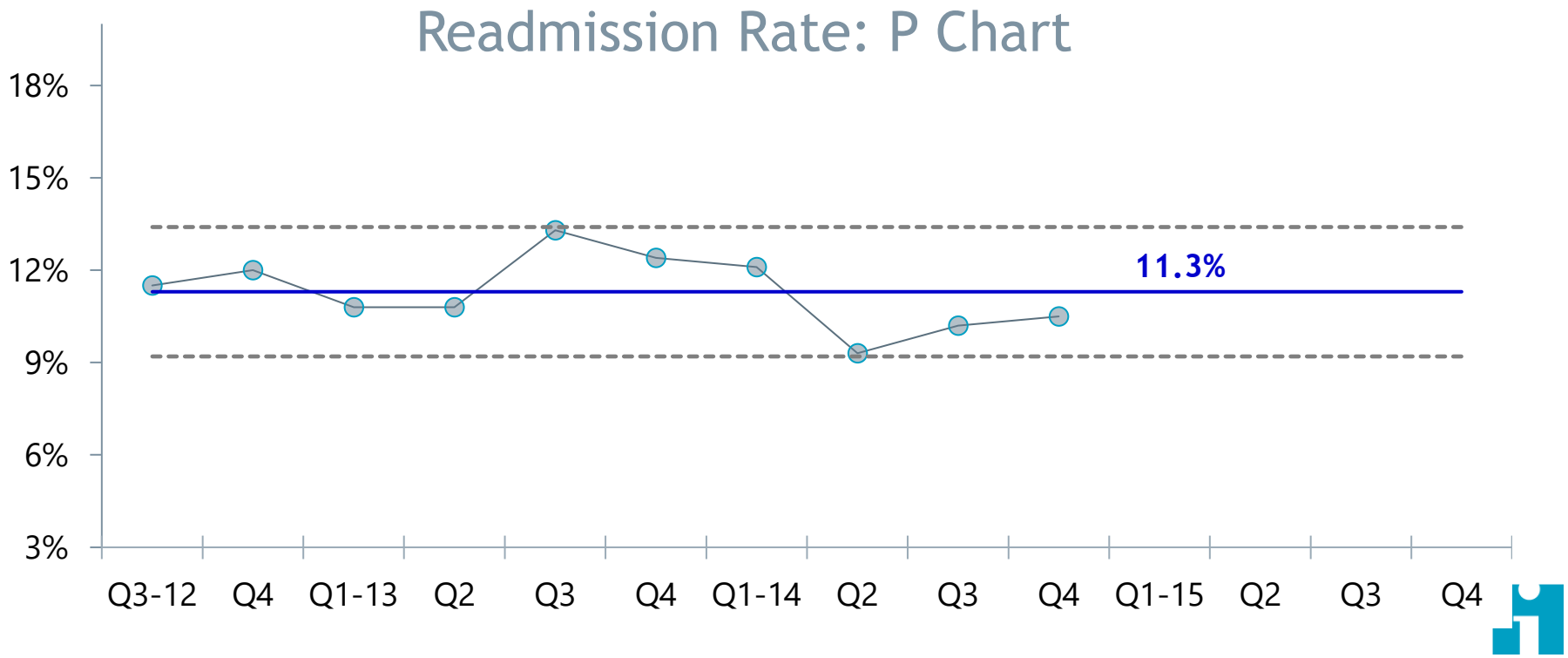
- Percent label redundant
- Lighten gridlines
- Remove chart border
- Abbreviate dates
- Delete legend and label series directly
- Adjust y-axis so limits use about 50% of scale range
- *What else?*



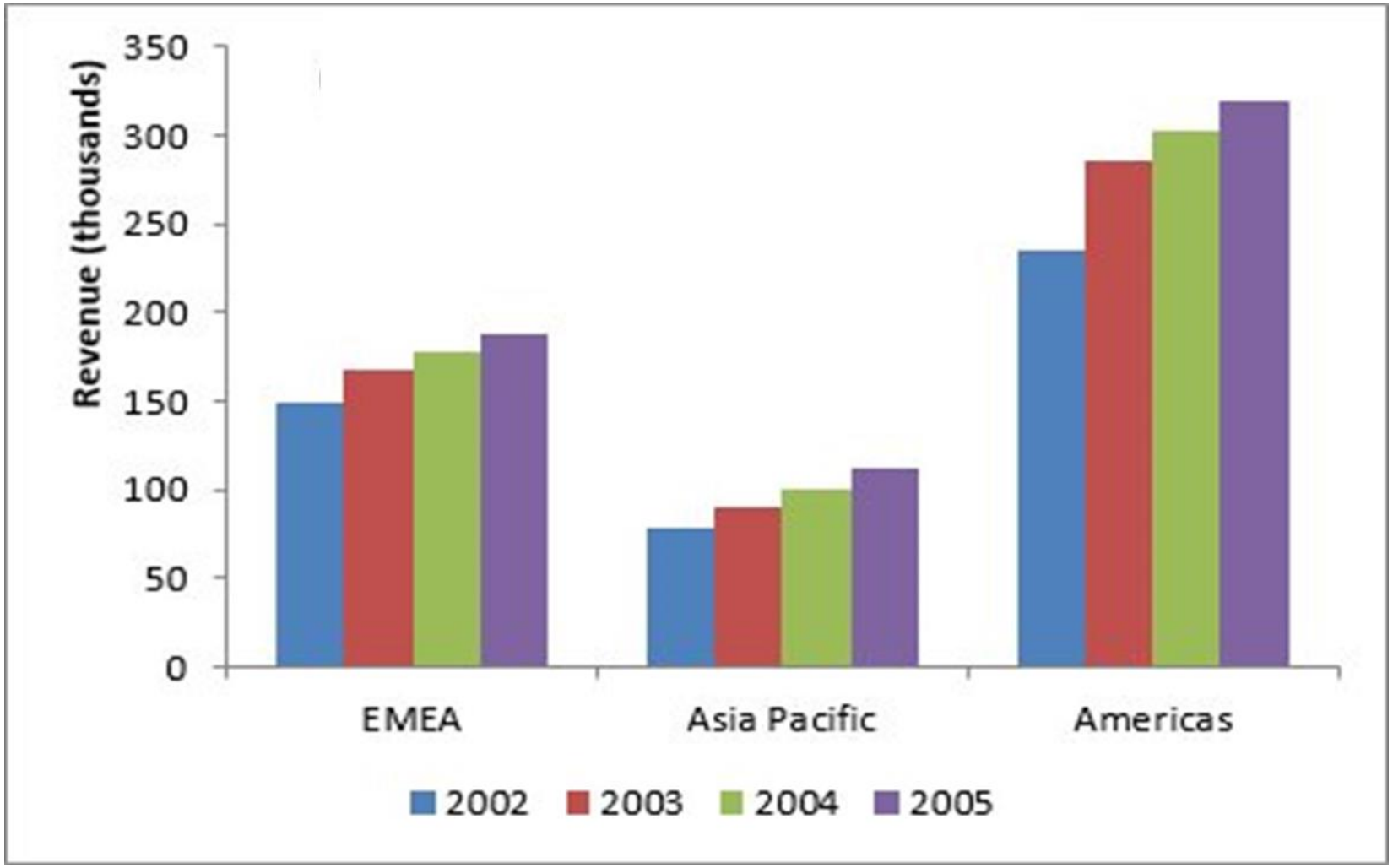
Opportunities for improvement?



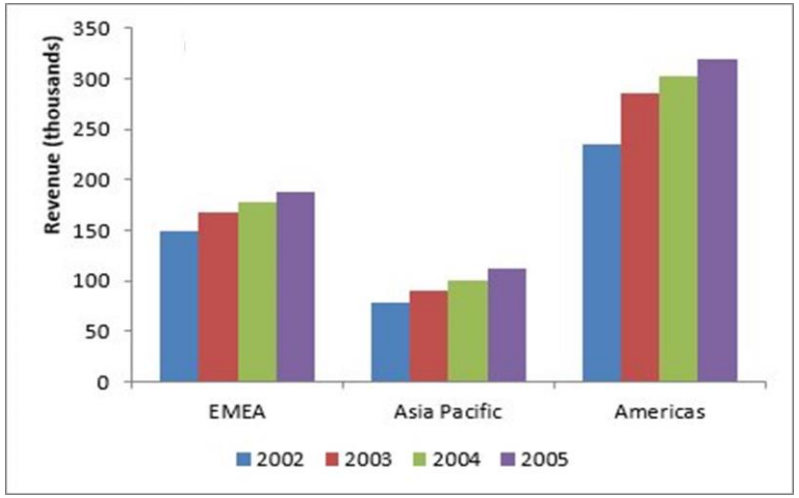
- Percent label redundant
- Lighten gridlines
- Remove chart border
- Abbreviate dates
- Delete legend and label series directly
- Adjust y-axis so limits use about 50% of scale range
- *What else?*

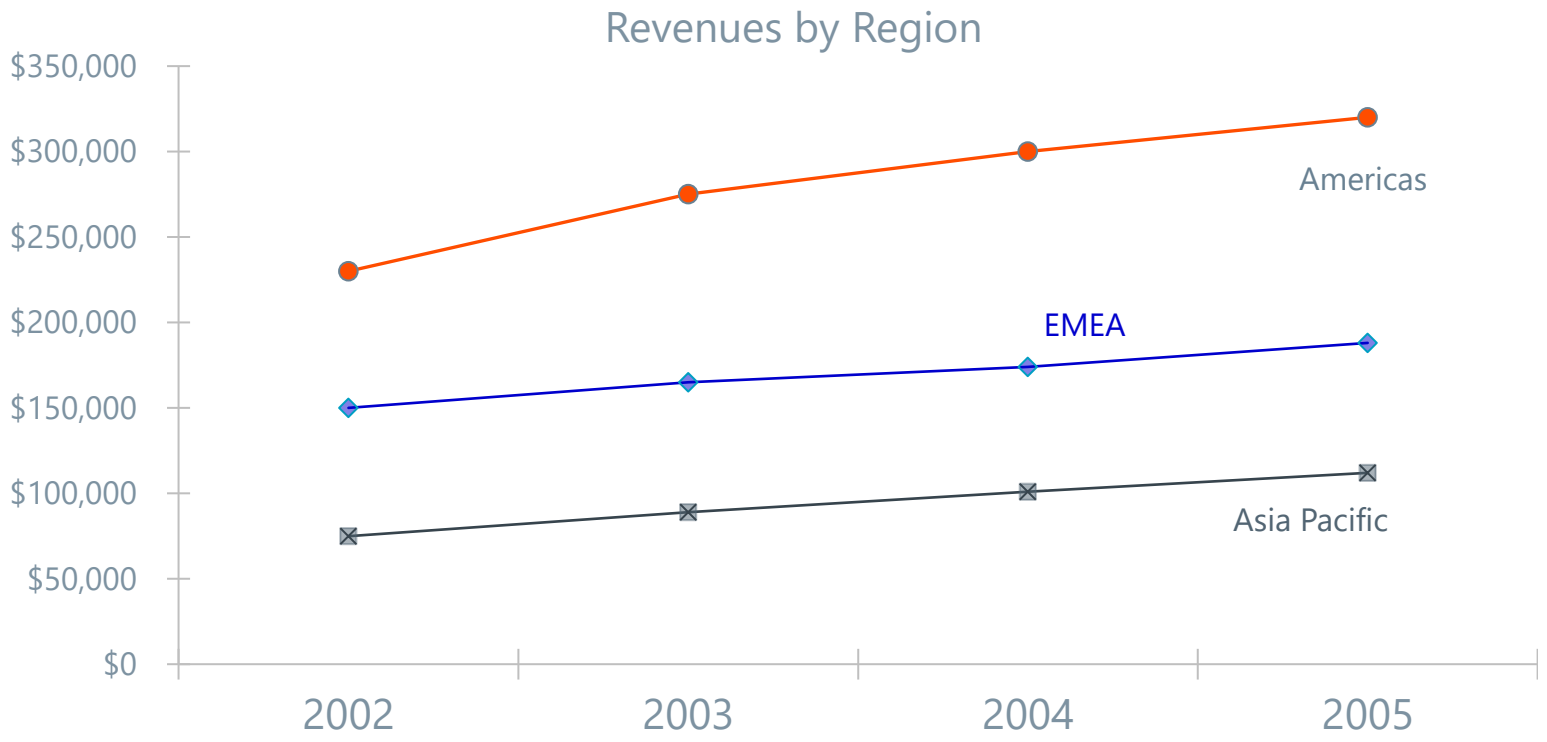


Apply your new insights about graphical excellence to improve Chart #2

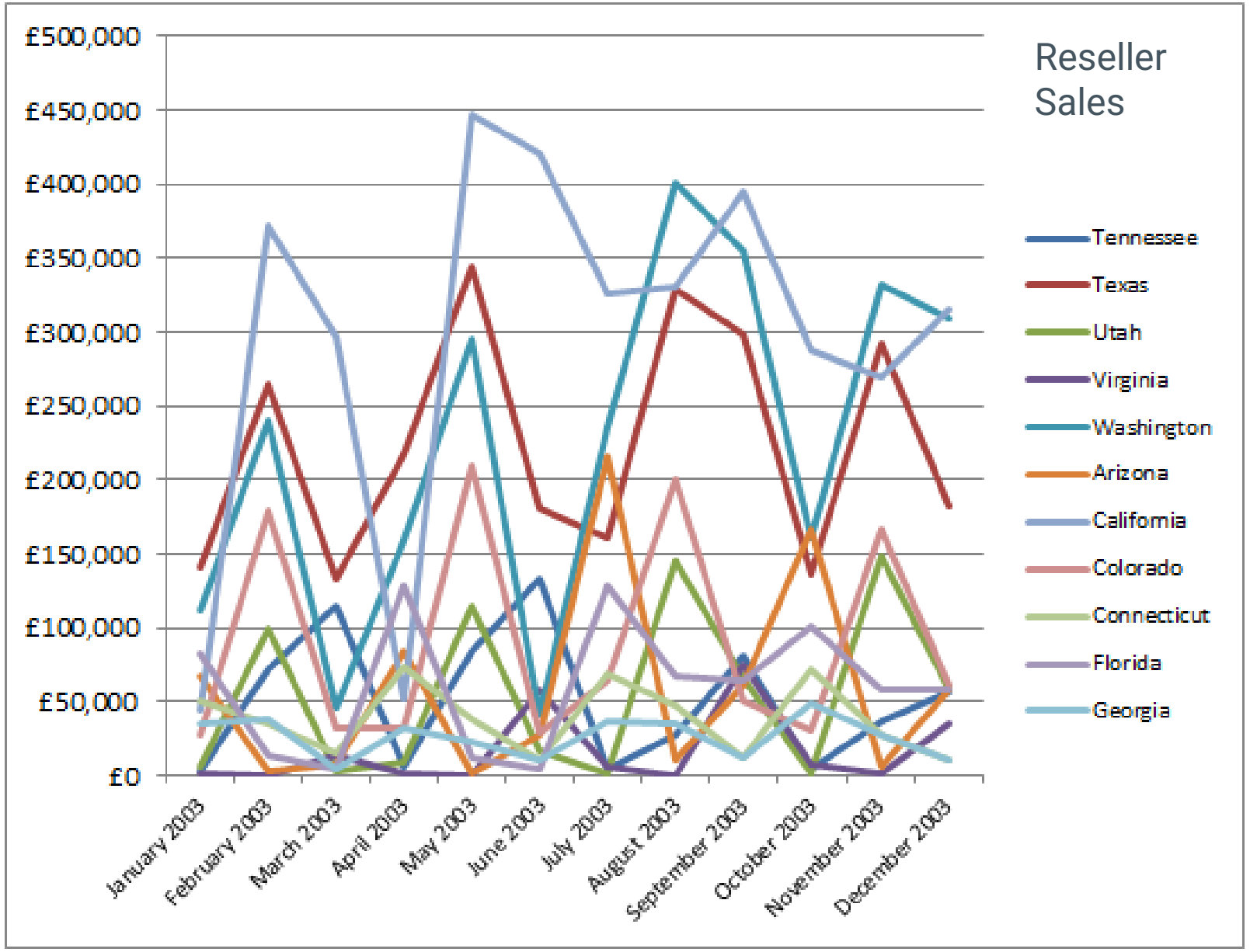


Opportunities for improvement?

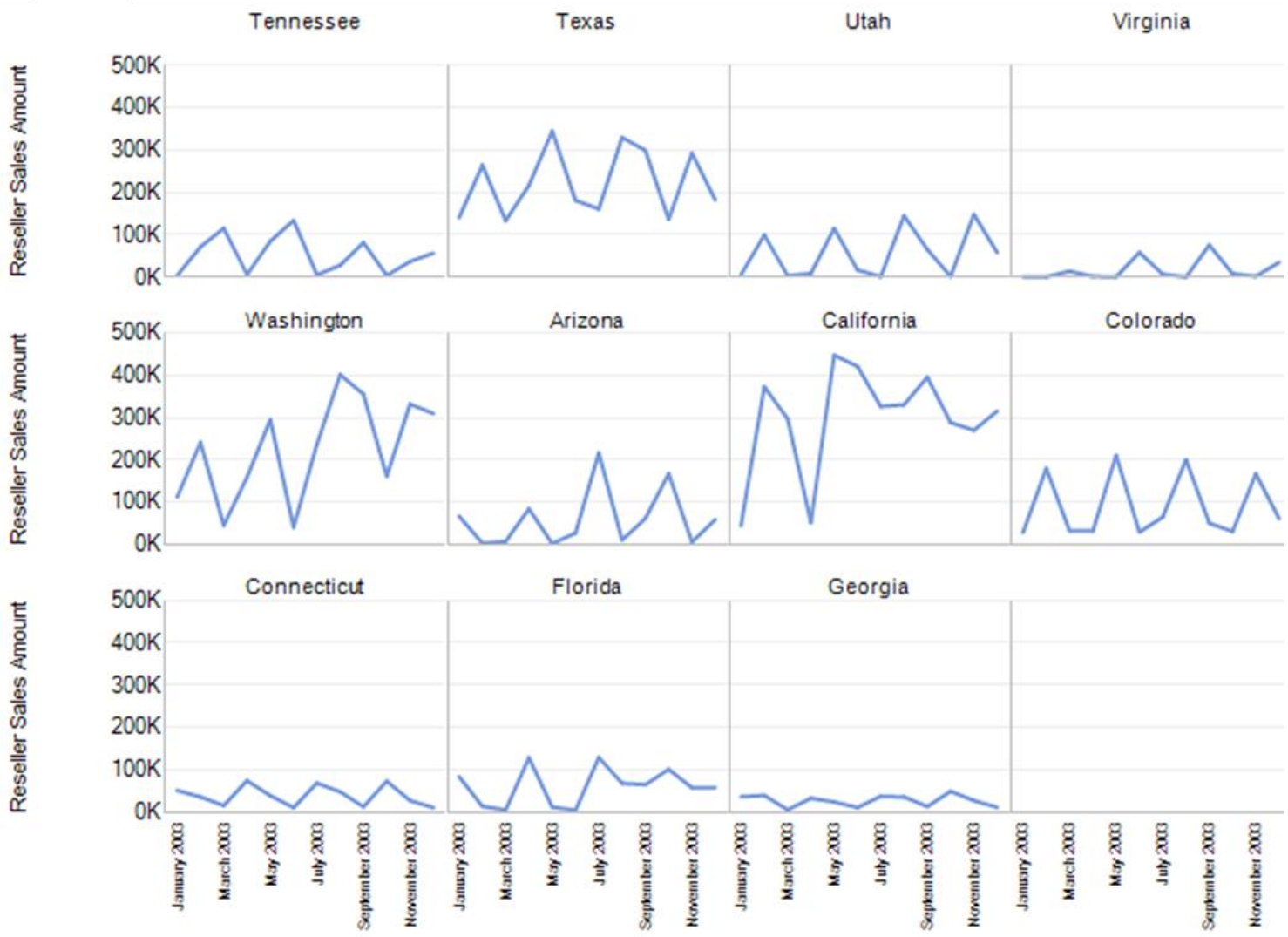




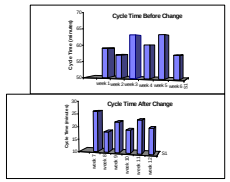
Apply your new insights about graphical excellence to improve Chart #3



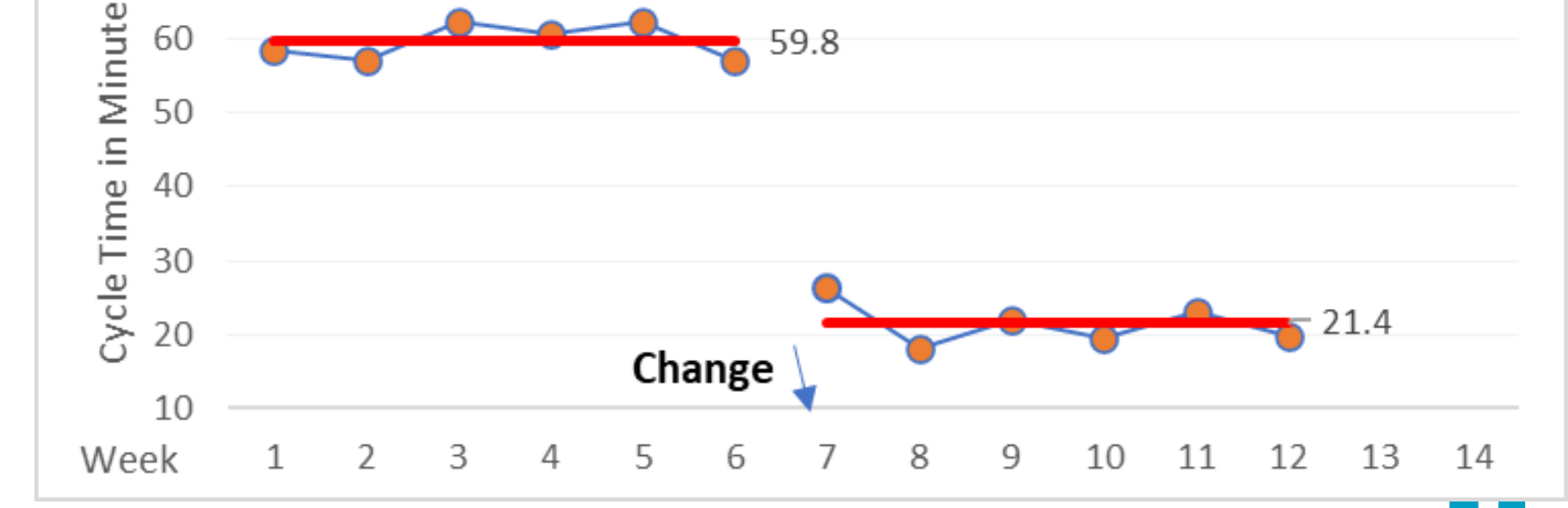
Opportunities for improvement?



Apply your new insights about graphical excellence to improve Chart #4

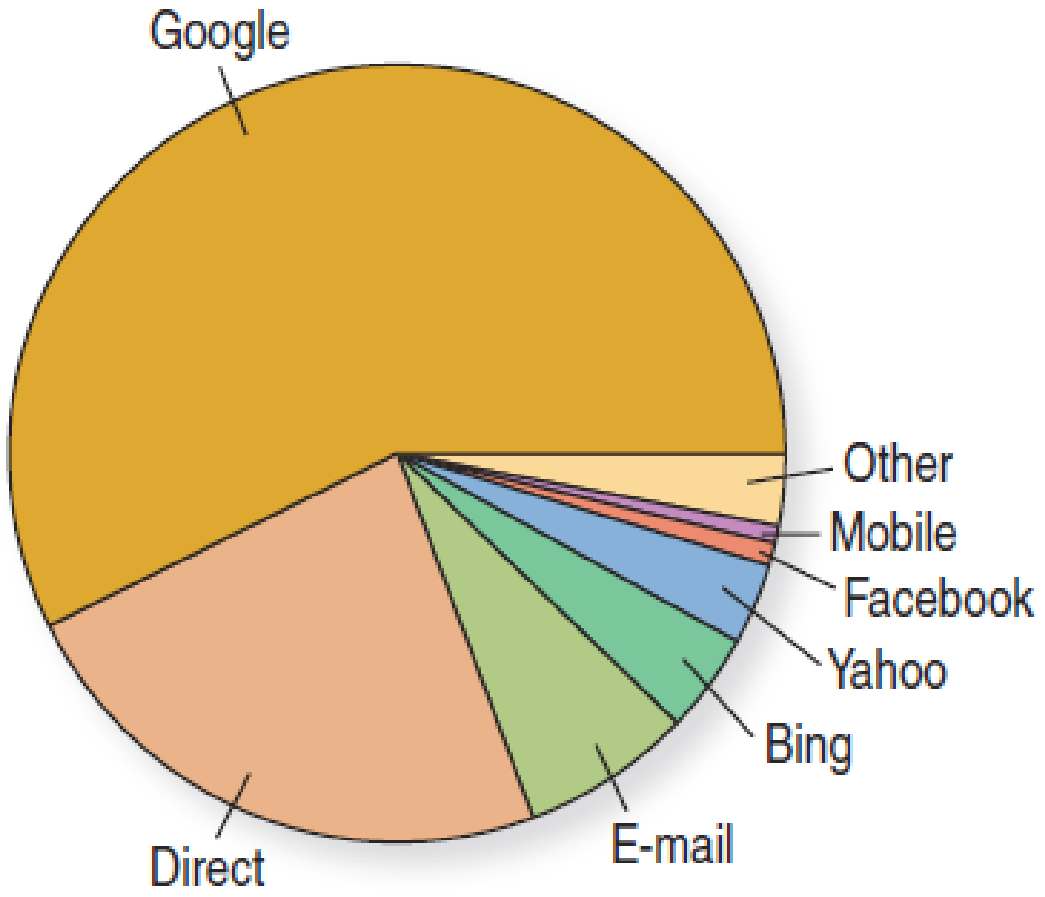


Opportunities for improvement?



EXTREME MAKEOVER
CHART EDITION

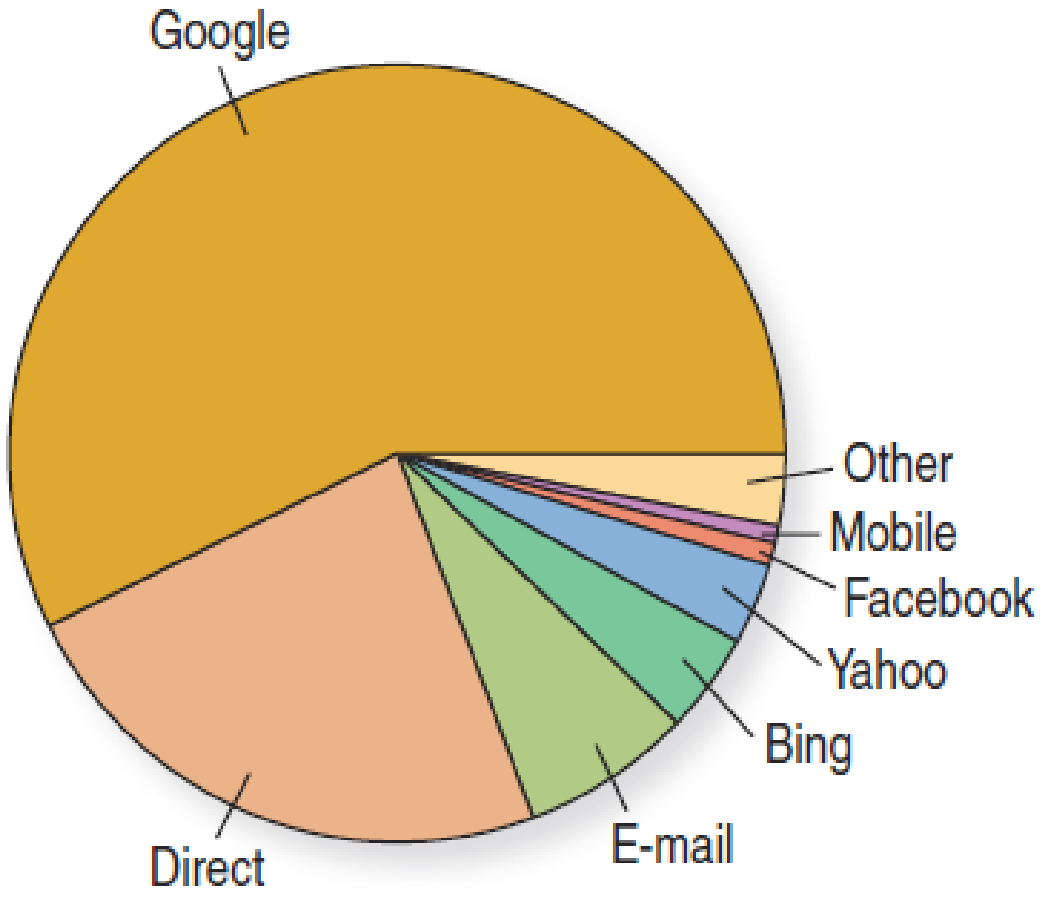
Source of website visitors



EXTREME MAKEOVER
CHART EDITION

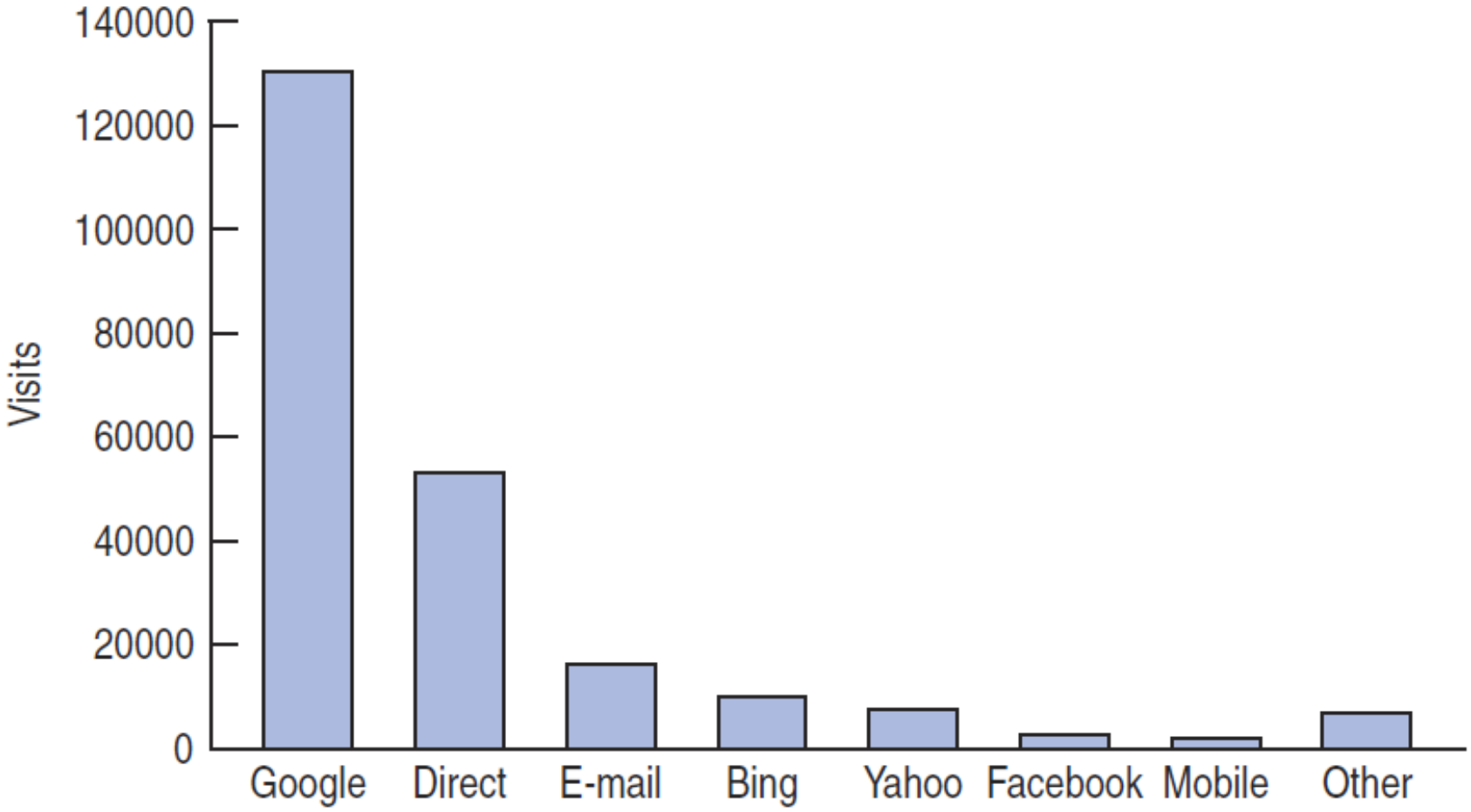
- Pie chart design makes it hard to differentiate between size of smaller segments
- Each category has its own color so colors convey no meaning
- No numerical information provided
- Needs informative title

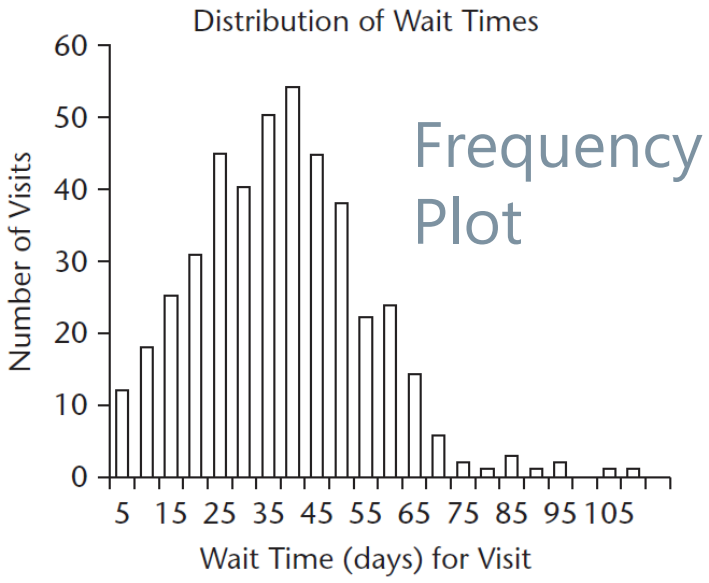
Source of website visitors



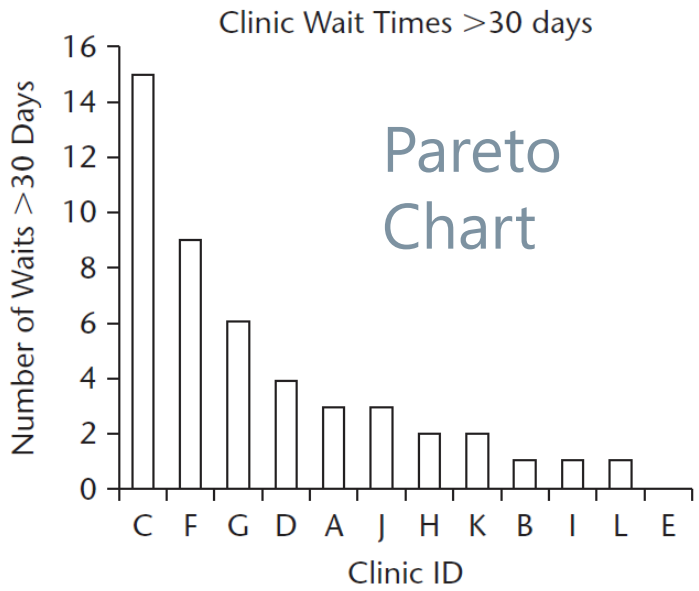
Alternative design?

How do customers find our website?
Site visit source counts during 2021:

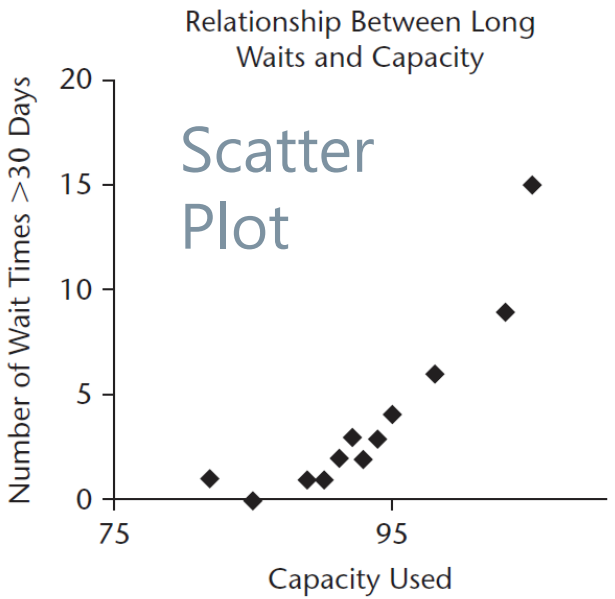




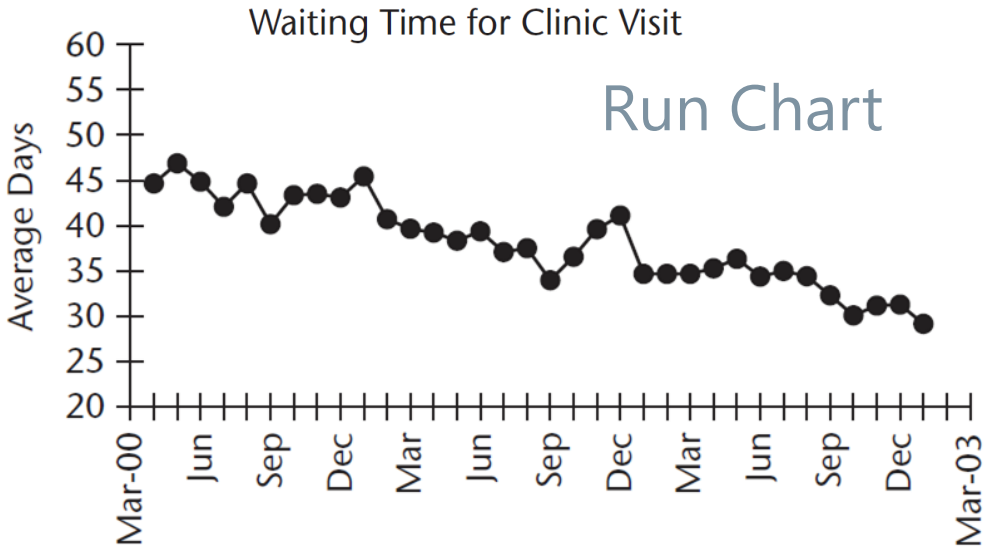
Frequency Plot



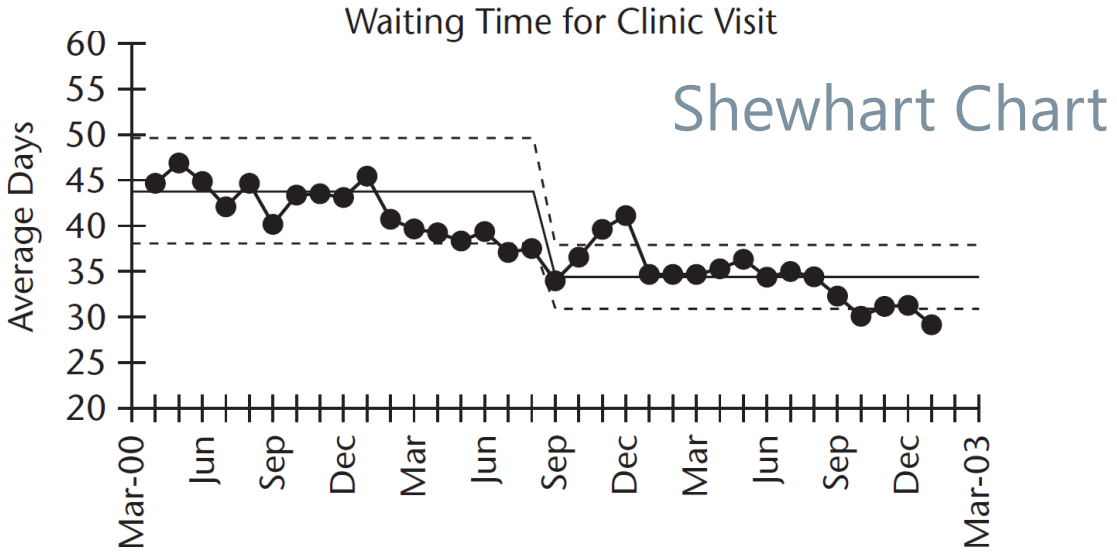
Pareto Chart



Scatter Plot

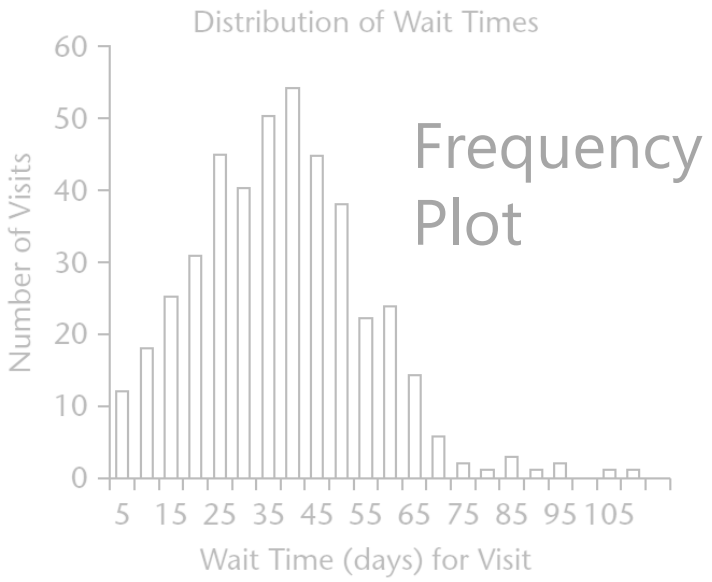


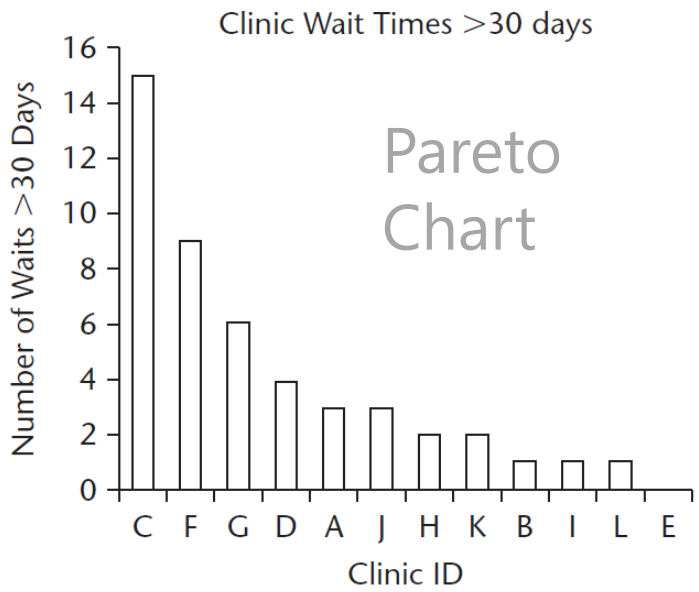
Run Chart

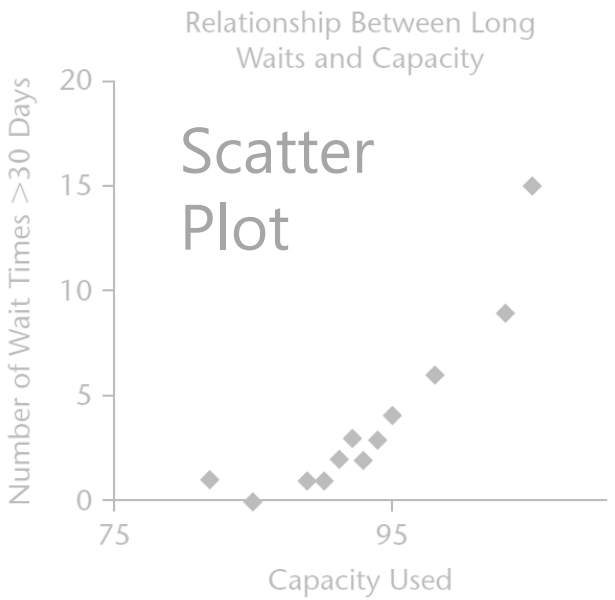


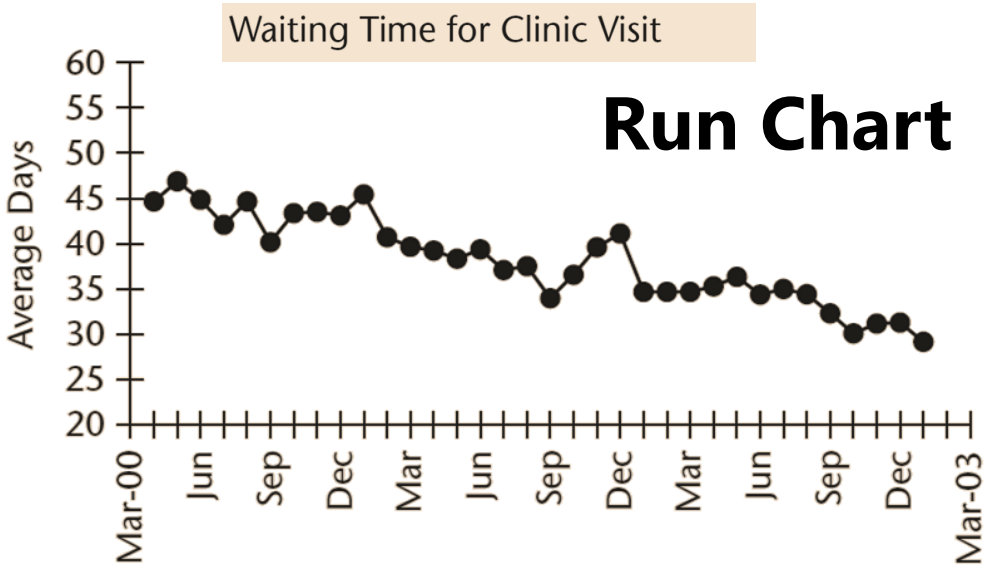
Shewhart Chart

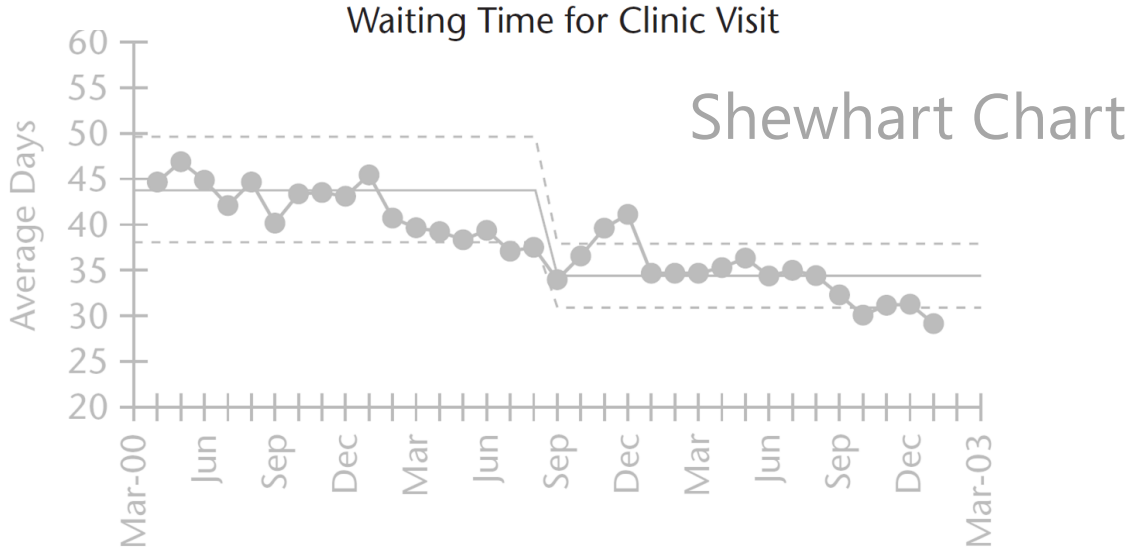
Five fundamental charts to visualize data for improvement







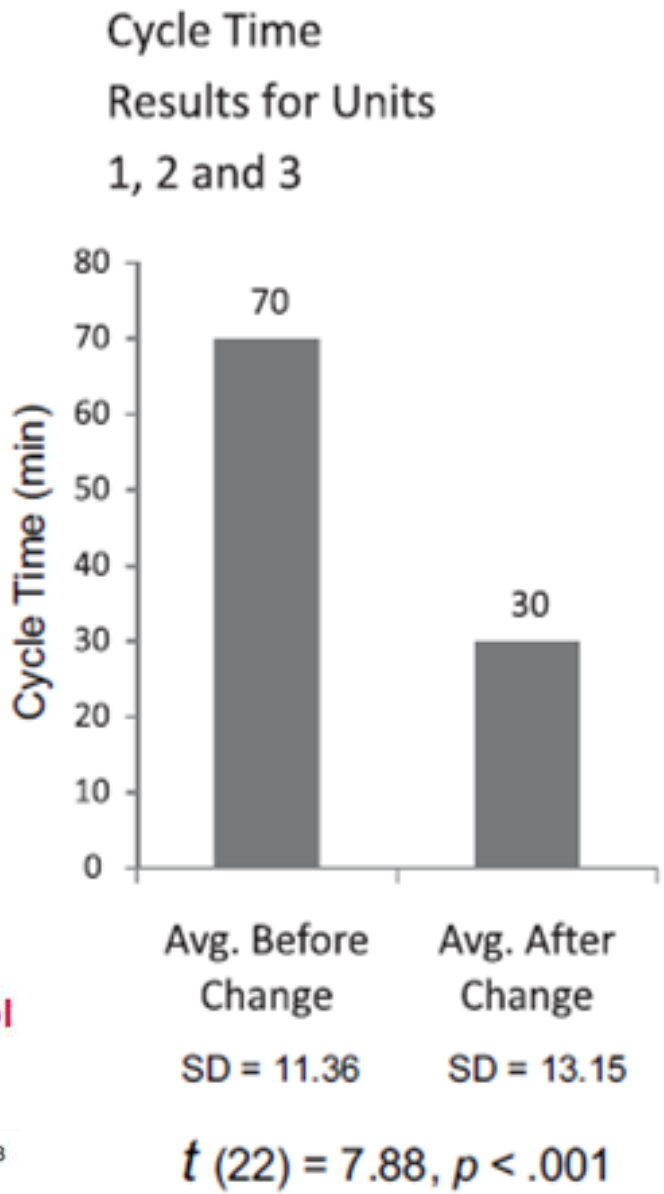




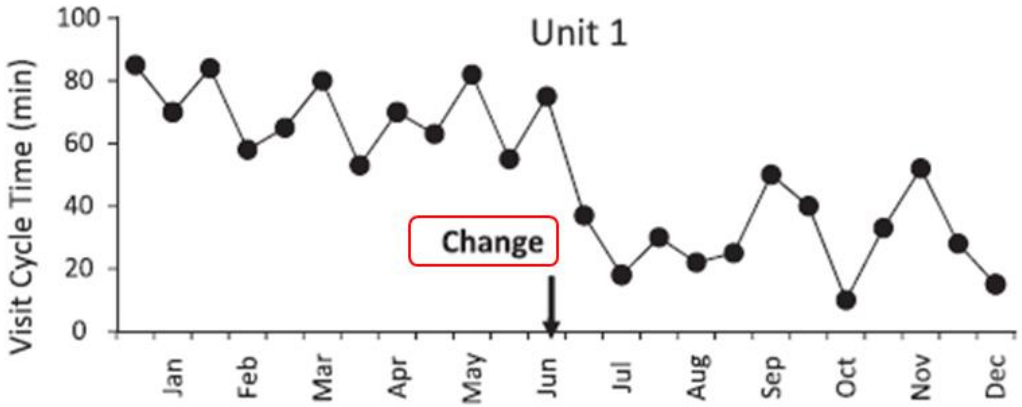
THE HEALTH CARE DATA GUIDE
LEARNING FROM DATA FOR IMPROVEMENT
LLOYD P. PROVOST SANDRA K. MURRAY

Why do we need to plot data over time?

The plot of points (in time order) conserves the information derived from the comparison or experiment and **offers insights about what to expect in the future**.



Does this change result in improvement?



The run chart: a simple analytical tool for learning from variation in healthcare processes

Rocco J Perla,[1] Lloyd P Provost,[2] Sandy K Murray[3]

BMJ Qual Saf 2011;**20**:46–51. doi:10.1136/bmjqs.2009.037895

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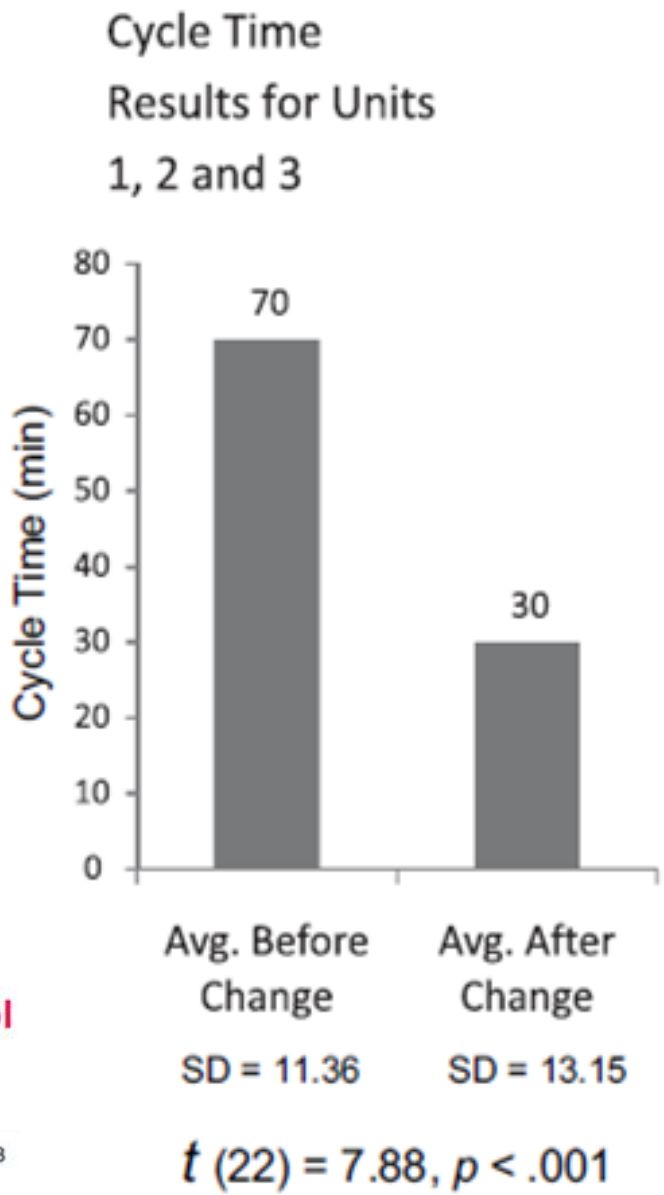

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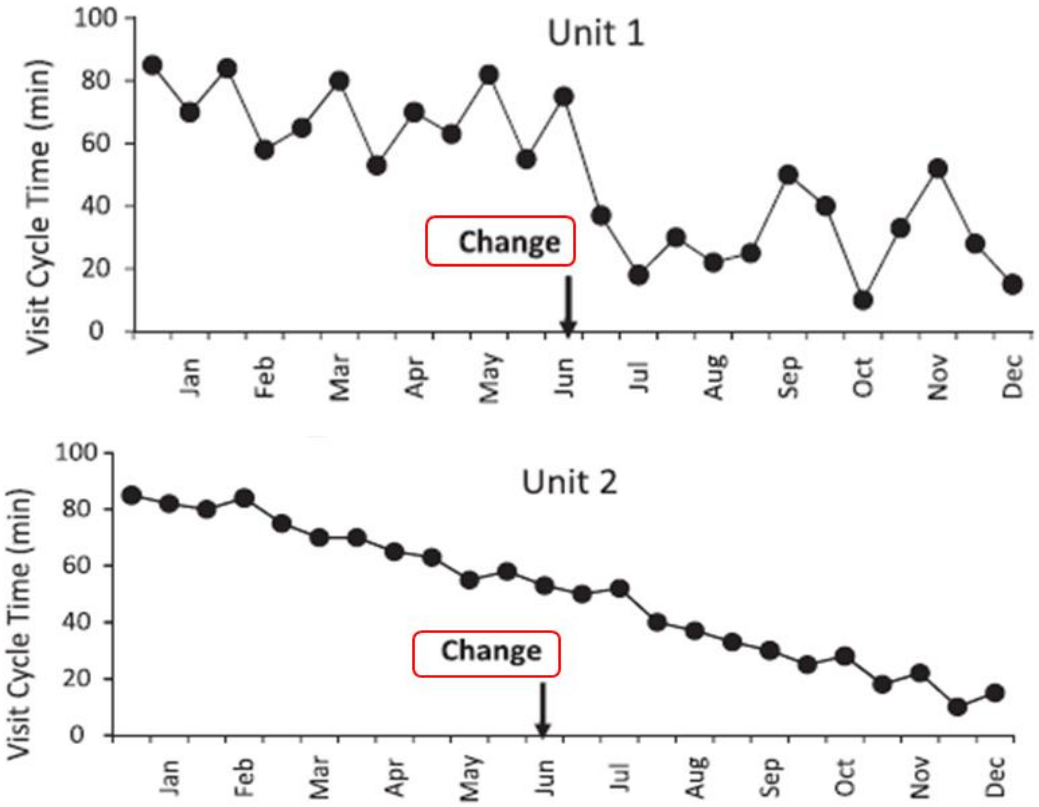

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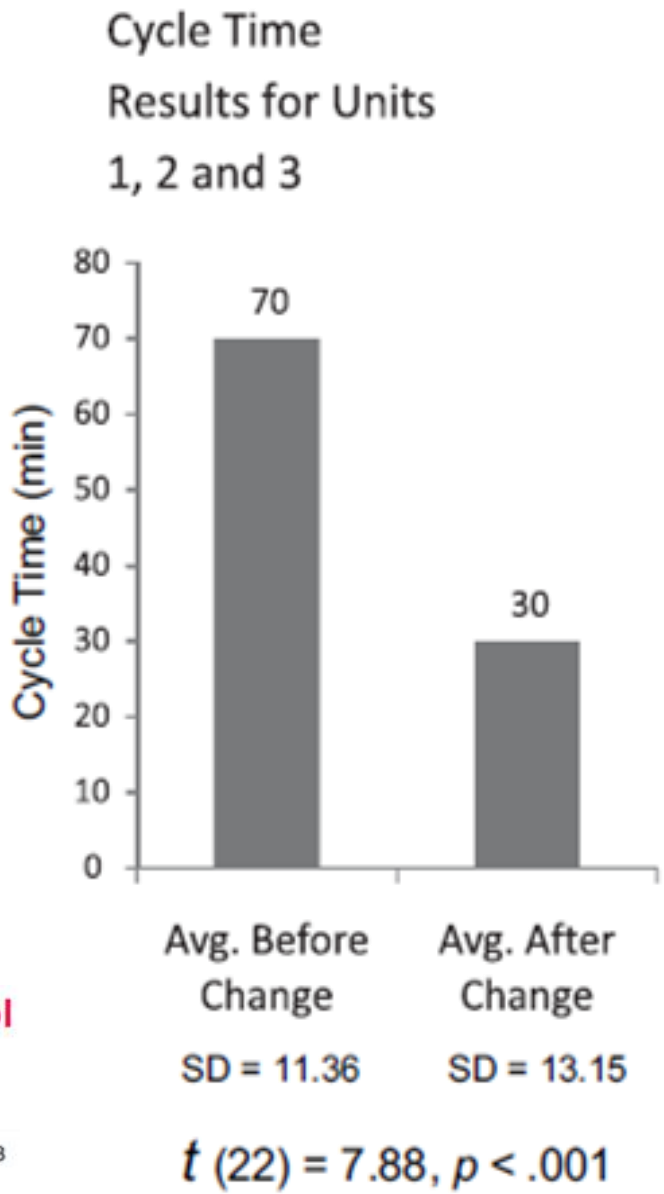

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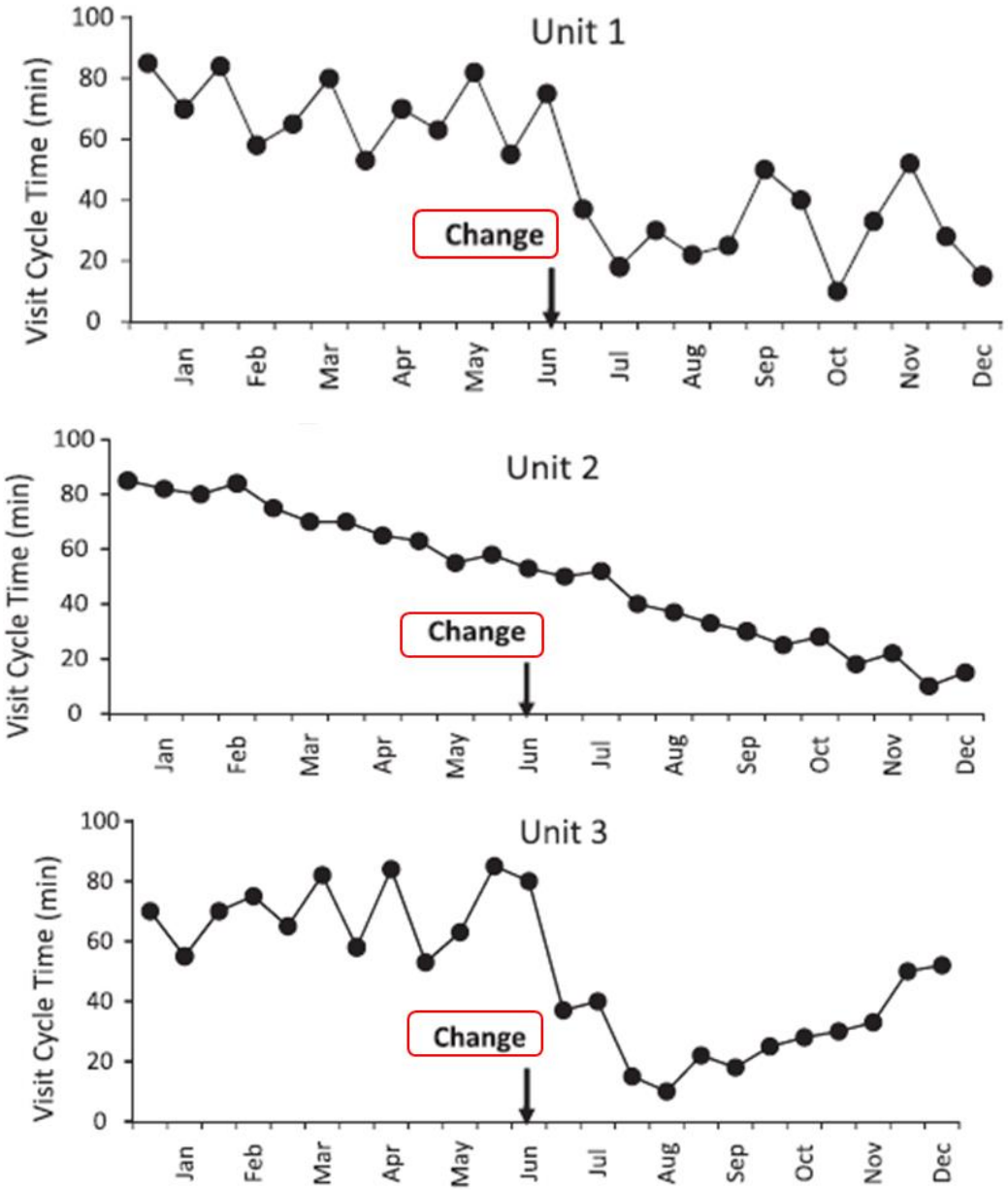

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"Plotting measurements over time turns out, in my view, to be one of the most powerful devices we have for systemic learning... Several important things happen when you plot data over time. First, you have to ask what data to plot. In the exploration of the answer you begin to clarify aims, and also to see the system from a wider viewpoint. *Where are the data? What do they mean? To whom? Who should see them? Why?* These are questions that integrate and clarify aims and systems all at once...

If you follow only one piece of advice from this lecture when you get home, pick a measurement you care about and begin to plot it regularly over time. You won't be sorry."

– Donald M. Berwick MD, 1995,
National Forum for Quality Improvement in Health Care

The run chart: a simple analytical tool for learning from variation in healthcare processes

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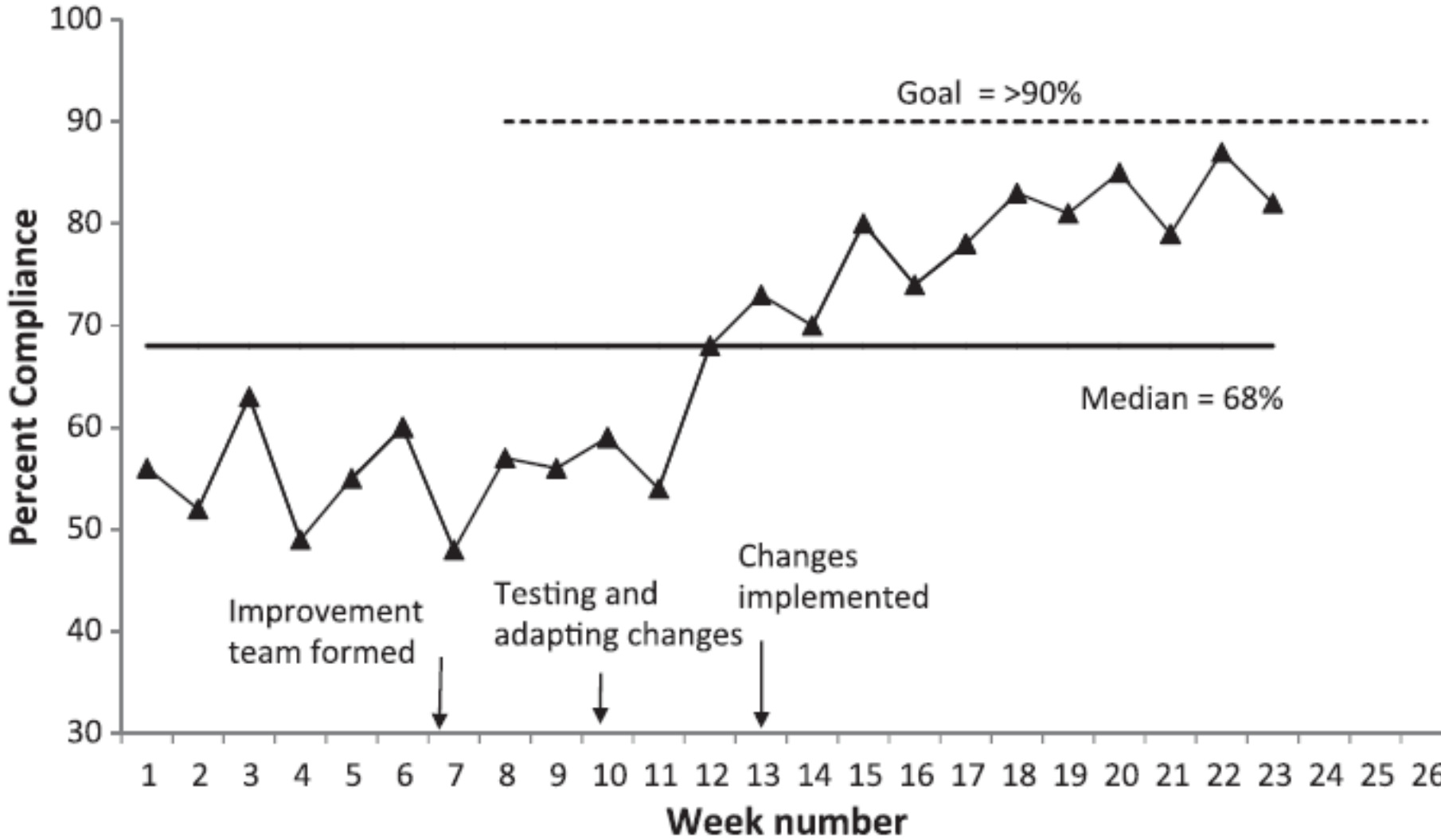
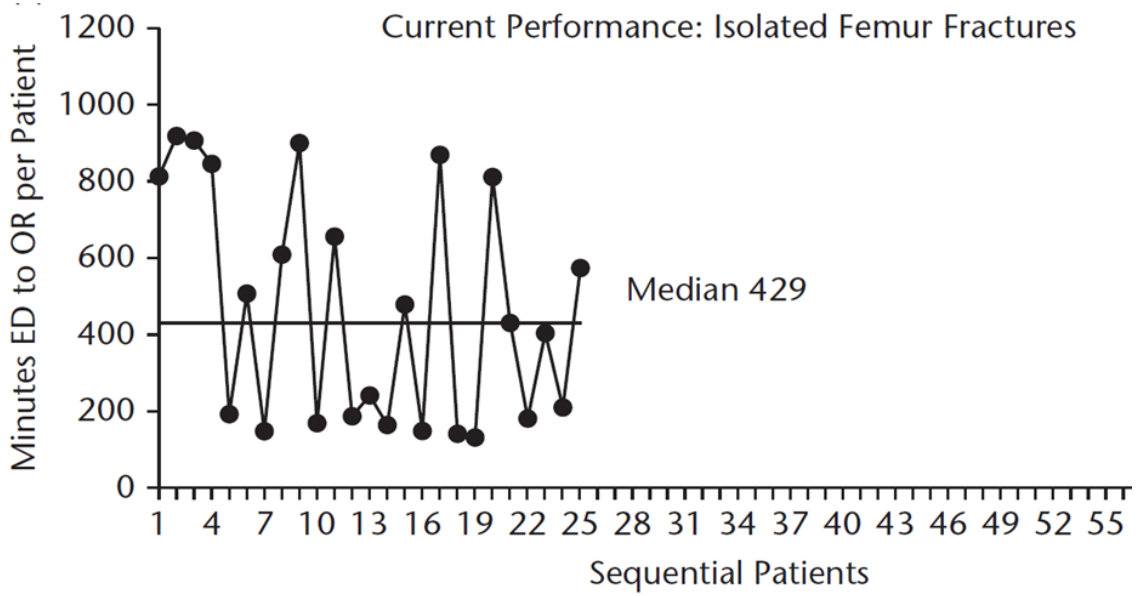
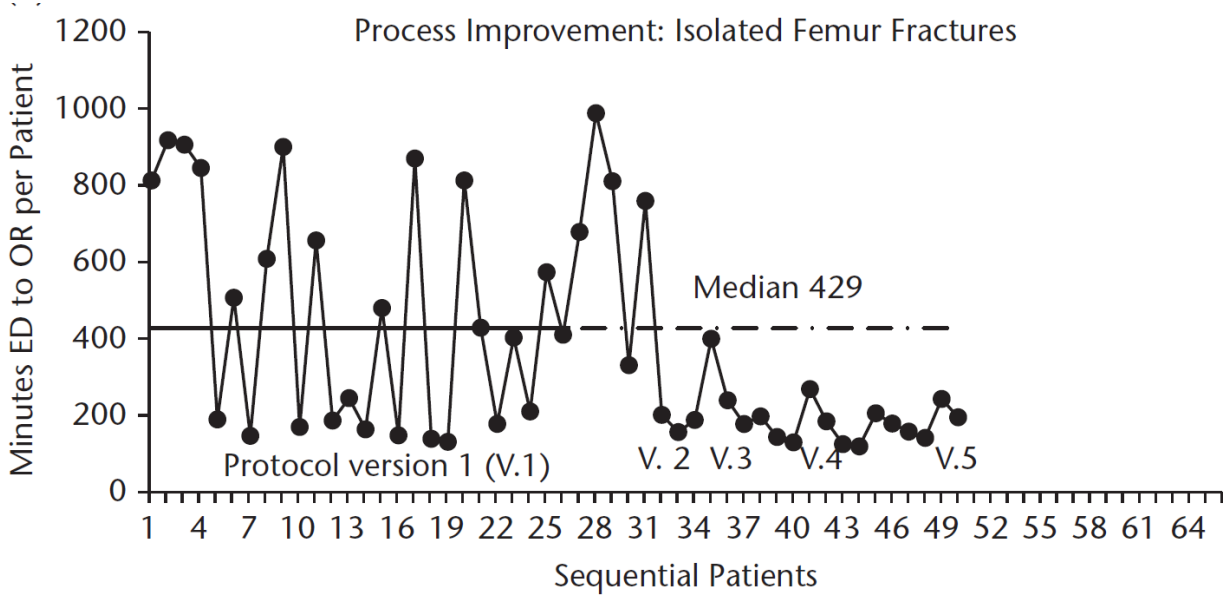


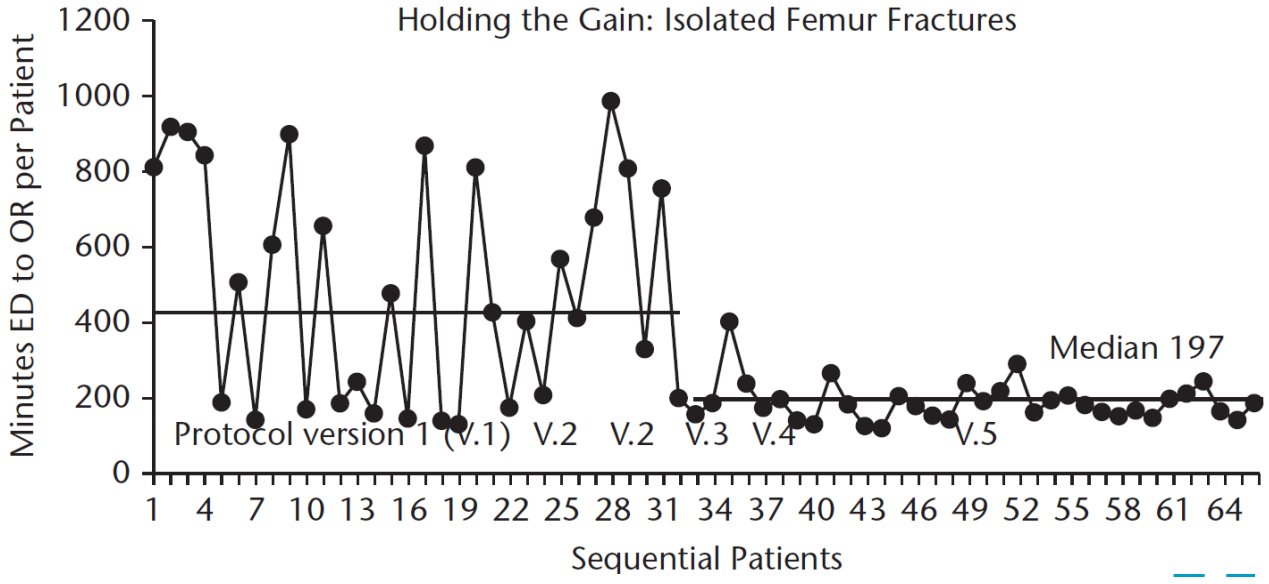
BMJ QUALITY & SAFETY

Using Run Charts to support improvement

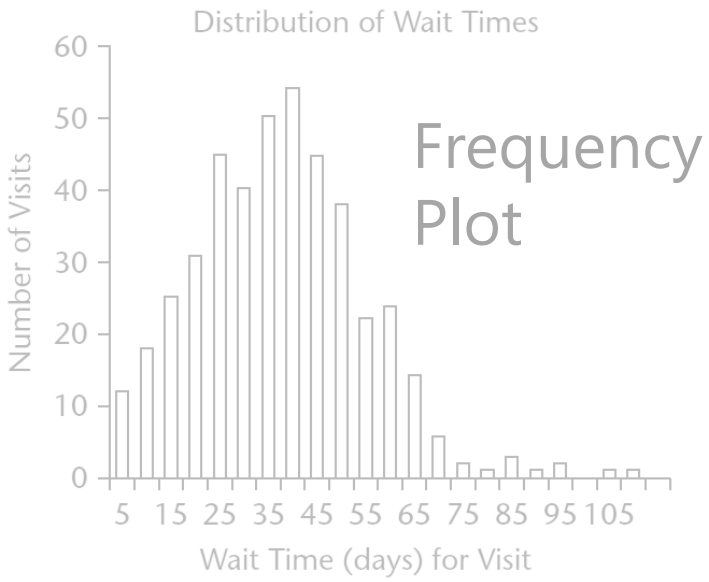
- Displaying data to make process performance visible
- Determining if changes tested resulted in improvement
- Determining if we are holding the gains made by our improvement
- Allowing for a temporal (analytic) view of data versus a static (enumerative) view

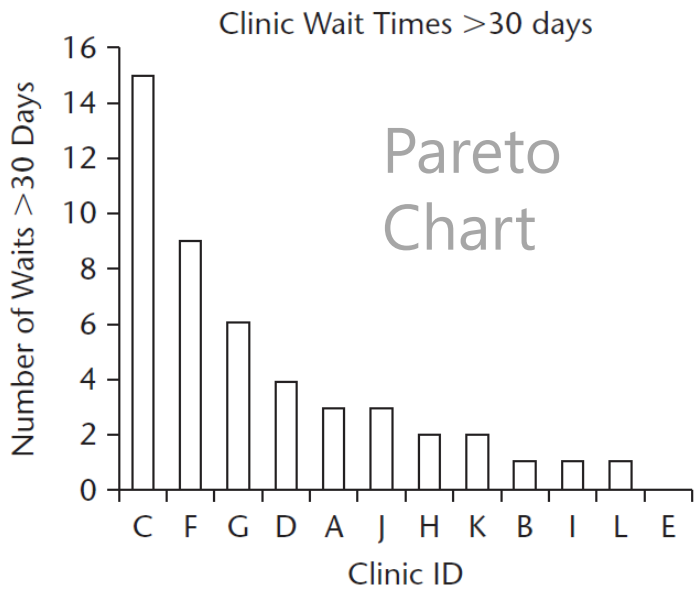


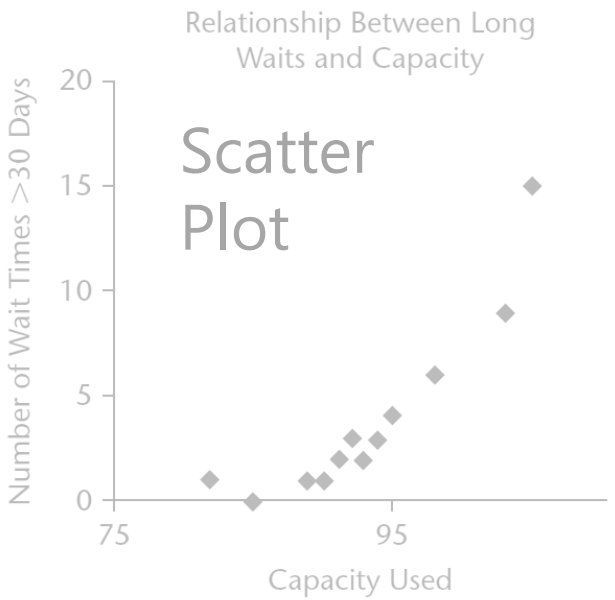


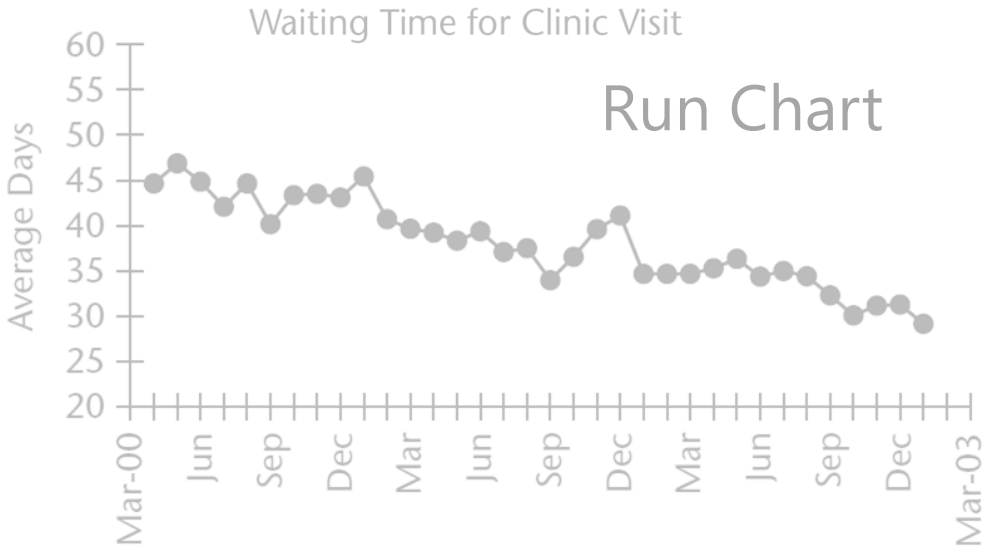


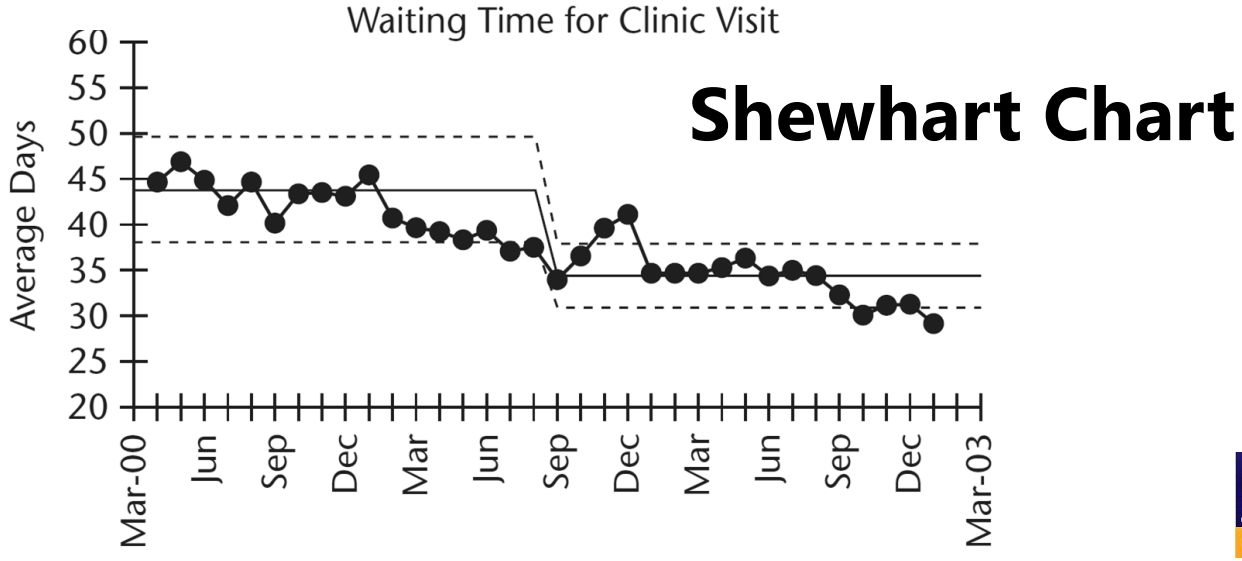
Five fundamental charts to visualize data for improvement





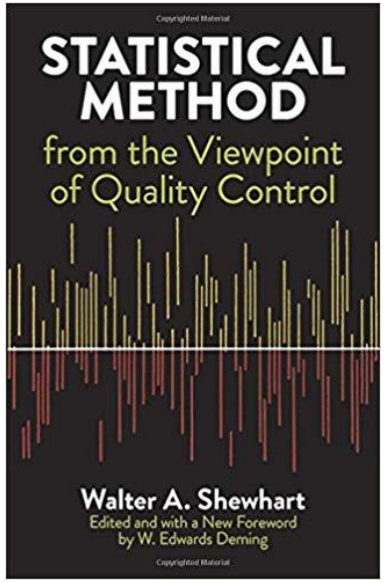






Shewhart's Theory of Variation

A fundamental concept of the science of improvement is that variation in a measure has two potential origins: **common causes** and **special causes**.



Walter A. Shewhart, Ph.D.
1891–1967

Another half-century may pass before the full spectrum of Dr. Shewhart's contributions has been revealed in liberal education, science, and industry.

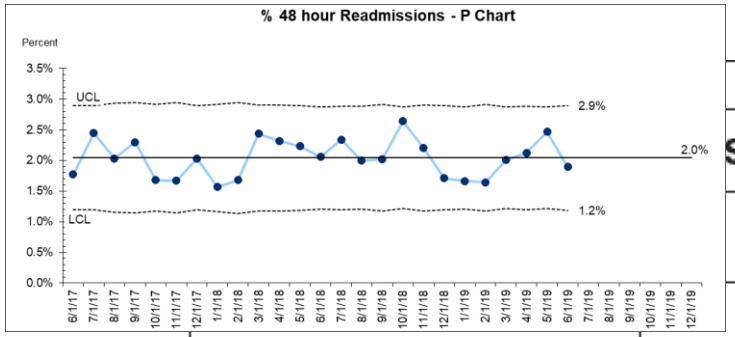
W. Edwards Deming

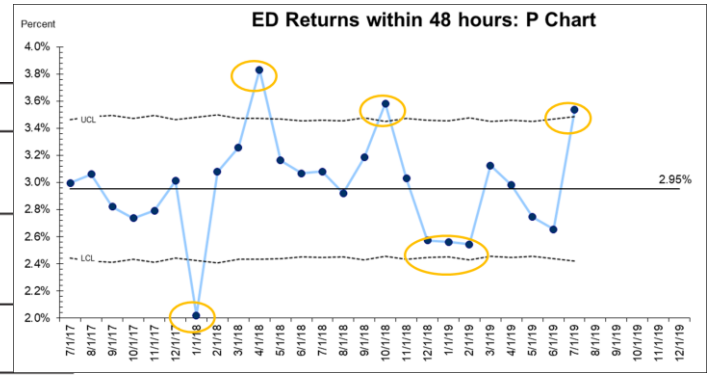
Common Causes are inherent in the system over time, affecting everyone working in the system and all system outcomes.

Special Causes are not part of the regular system but arise because of particular circumstances or some "special" source of variation that can be assigned to some identifiable cause

HC Data Guide, p. 124

Use of Shewhart's Theory to Guide Improvement





Select a Key Measure Related to the Aim of the Improvement Effort

Develop an Appropriate Shewhart Chart for the Measure

Is the System Stable Related to this Measure?

Yes

Identify Common Cause(s)
Tools/Methods:
-PDSA Tests of Change
-Cause and Effect Diagram
-Rational Subgrouping
-Planned Experimentation
Responsibility:*
1. Subject or technical experts
2. People working inside the healthcare process(es)
3. Patients and family

Change the System to Remove or Reduce Common Cause(s) of Variation
Responsibility:*
1. Healthcare management at the appropriate level

No

Identify Special Cause(s)
Tools/Methods:
-Shewhart Charts
-Cause and Effect Diagram
-Rational Subgrouping
-PDSA Tests
Responsibility:*
1. People working inside the healthcare process(es)
2. Local healthcare management
3. Subject or technical experts

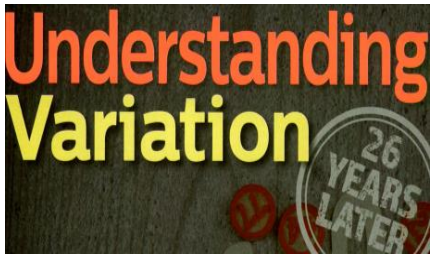
Learrn from and Act on Special Cause(s)
Responsibility:*
1. Local process supervisors (e.g charge nurse)
2. Subject or technical experts (e.g. infection control)
3. Healthcare managment at the appropriate level

*Lists are ordered by importance

HC Data Guide, Figure 4.1, p. 128

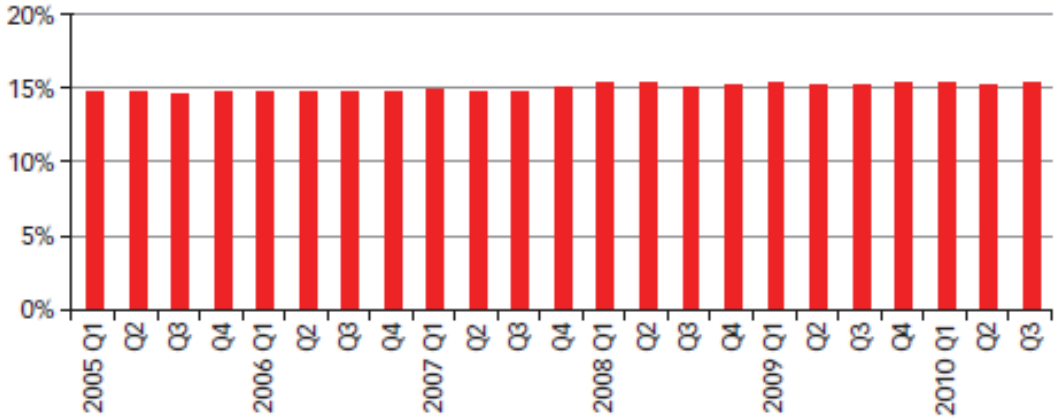
Correctly assessing variation is fundamental to sound decisions

by Thomas Nolan, Rocco J. Perla and Lloyd Provost



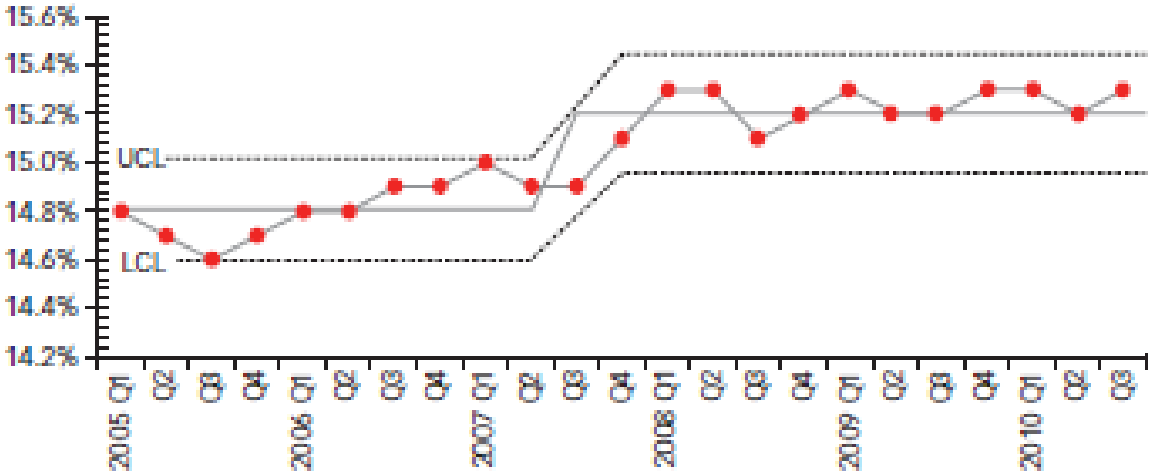
www.qualityprogress.com
November 2016

Nursing facility residents with one or more falls with major injury / FIGURE 2



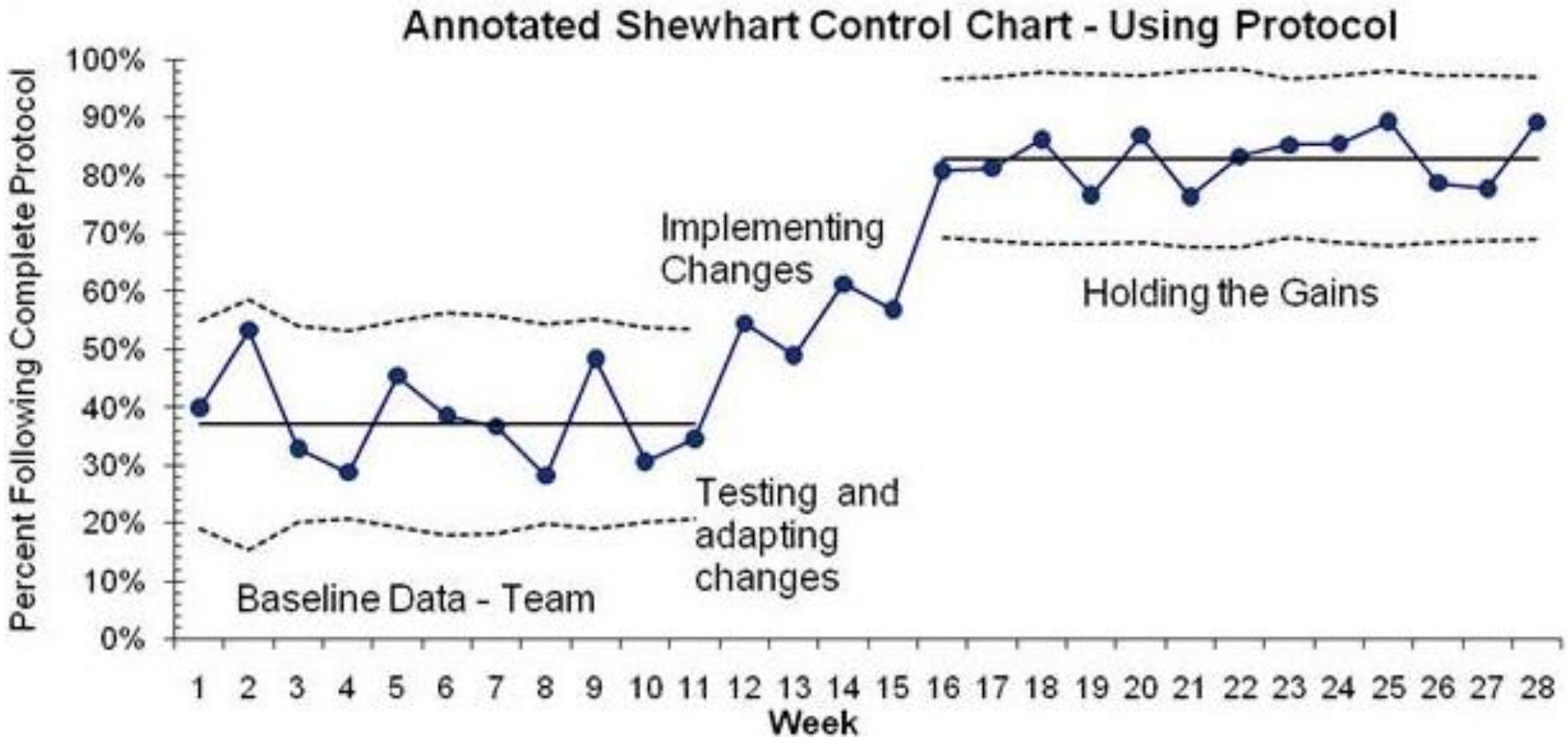
Source: U.S. Department of Health and Human Services, "Health System Measurement Project," https://healthmeasures.aspe.hhs.gov.

Nursing facility residents with one or more falls with major injury (including pre and postshift phases) / FIGURE 4



Shewhart Charts (also commonly known as Control Charts)

These tools provide a basis for taking action in improvement efforts for reasons that include capacity to distinguish *common cause variation* from *special cause variation* in a measure.

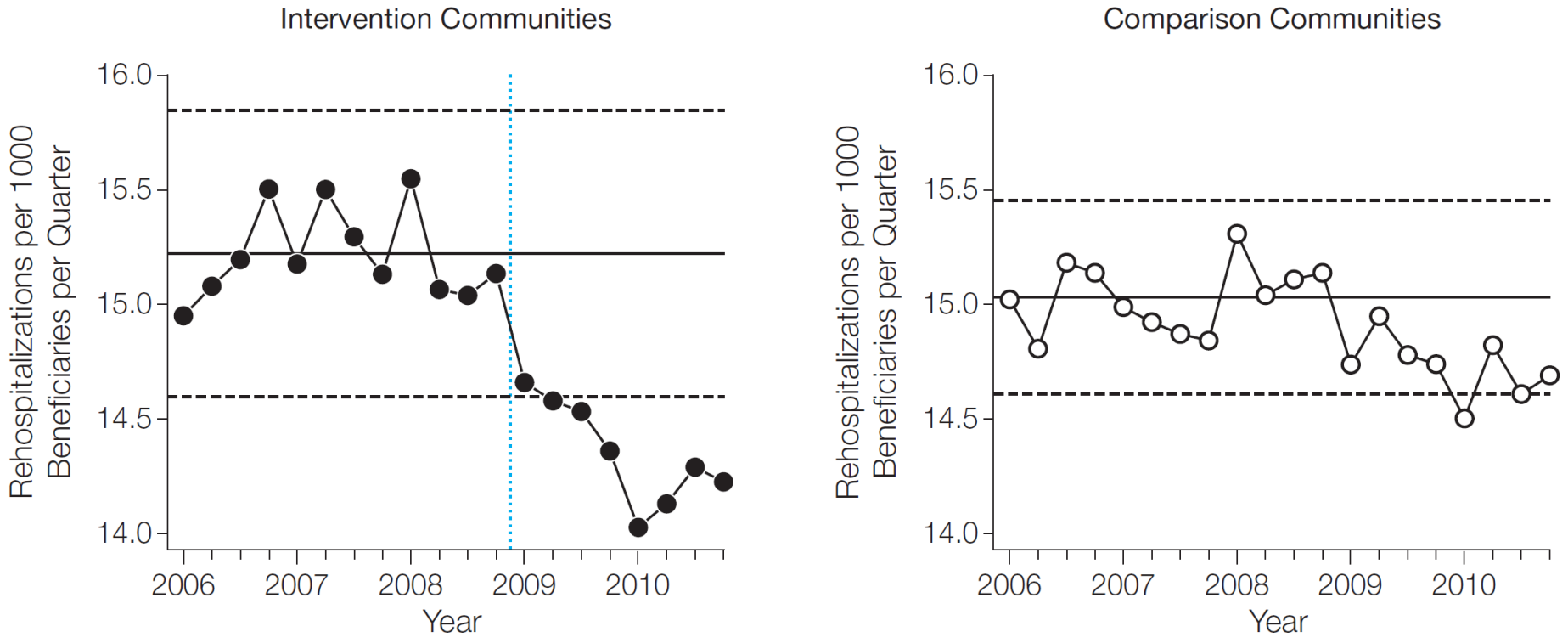


Association Between Quality Improvement for Care Transitions in Communities and Rehospitalizations Among Medicare Beneficiaries

Shewhart charts in the literature

Jane Brock, MD, MSPH
Jason Mitchell, MS
Kimberly Irby, MPH
Beth Stevens, MS
Traci Archibald, OTR/L, MBA
Alicia Goroski, MPH
Joanne Lynn, MD, MA, MS
for the Care Transitions Project Team

Figure 1. Process Control Charts for 30-Day All-Cause Rehospitalizations per 1000 Medicare Beneficiaries per Quarter, 2006-2010



Means (solid lines) and upper and lower control limits (dashed lines) set by the experience of 2006-2008. Vertical dotted line indicates start of quality improvement in the intervention communities.

JAMA The Journal of the American Medical Association
January 23/30, 2013—Vol 309, No. 4

Effect of monitoring surgical outcomes using control charts to reduce major adverse events in patients: cluster randomised trial

Antoine Duclos,[1,2,3] François Chollet,[2] Léa Pascal,[2] Hector Ormando,[4] Matthew J Carty,[3] Stéphanie Polazzi,[1,2] Jean-Christophe Lifante,[1,5] on behalf of the SHEWHART Trial Group

BMJ 2020;371:m3840

OBJECTIVE

To determine the effect of introducing prospective monitoring of outcomes using control charts and regular feedback on indicators to surgical teams on major adverse events in patients.

DESIGN

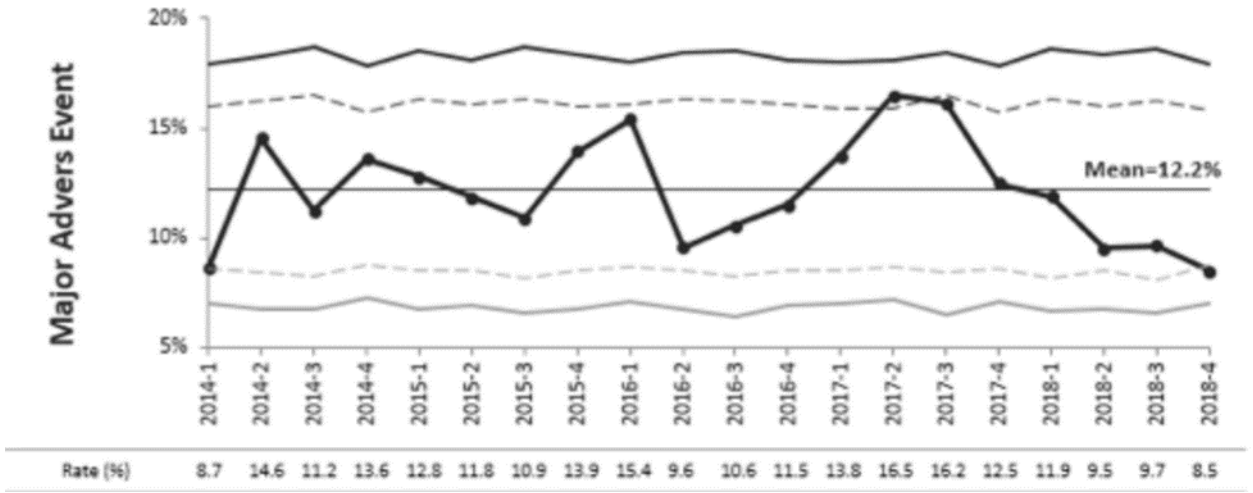
National, parallel, cluster randomised trial embedding a difference-in-differences analysis.

SETTING

40 surgical departments of hospitals across France.

PARTICIPANTS

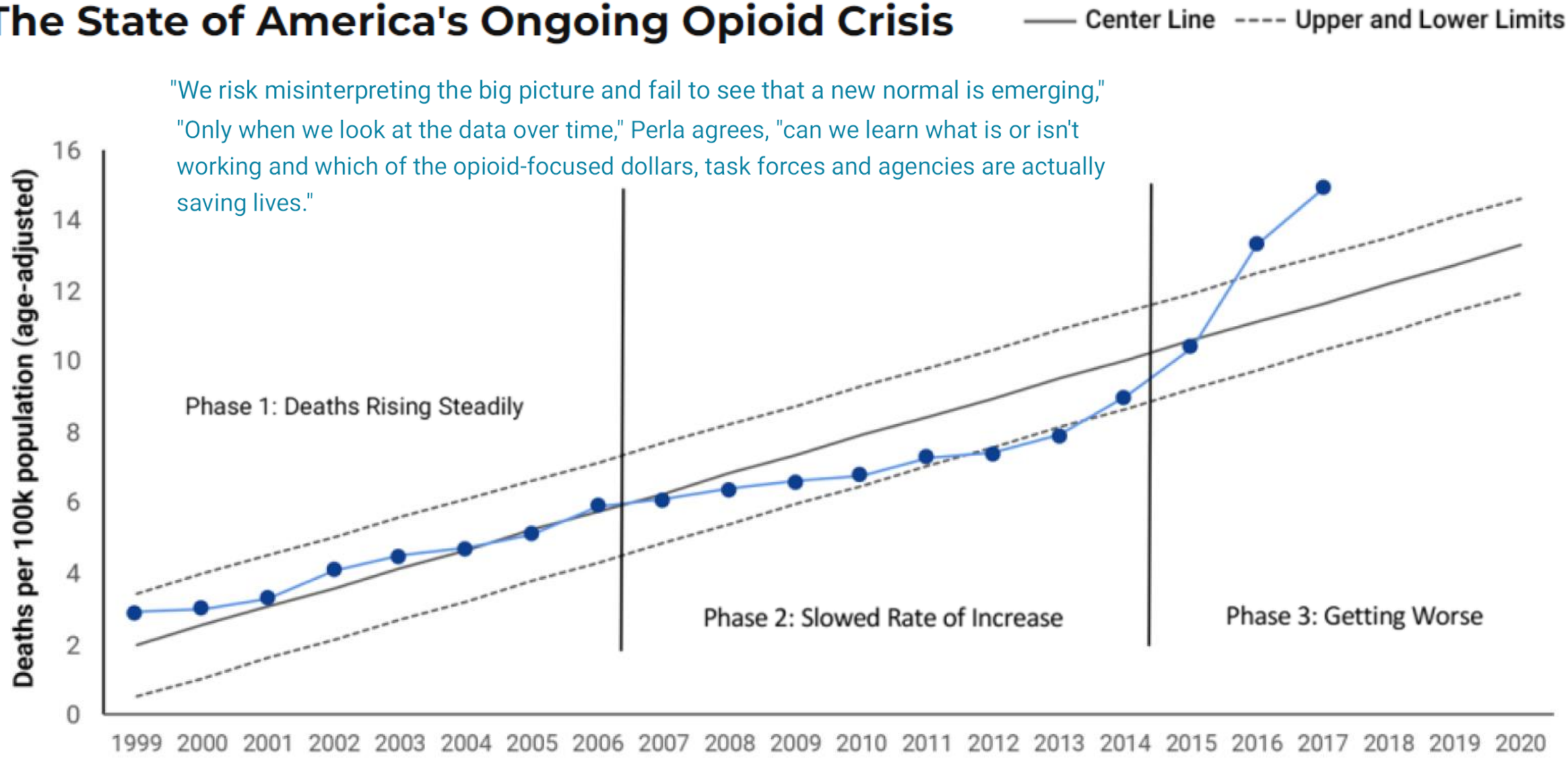
155 362 adults who underwent digestive tract surgery. 20 of the surgical departments were randomised to prospective monitoring of outcomes using control charts with regular feedback on indicators (intervention group) and 20 to usual care only (control group).



CONCLUSIONS

The implementation of control charts with feedback on indicators to surgical teams was associated with concomitant reductions in major adverse events in patients. Understanding variations in surgical outcomes and how to provide safe surgery is imperative for improvements.

The State of America's Ongoing Opioid Crisis



In this data visualization (called a control chart), the solid gray line in the center represents the average death rate over time. Notable changes occur when eight consecutive data points are above or below the center line, or when a data point falls outside the limits.

Source: Rocco Perla of The Health Initiative and Lloyd Provost of Associates in Process Improvement, using Centers for Disease Control and Prevention data

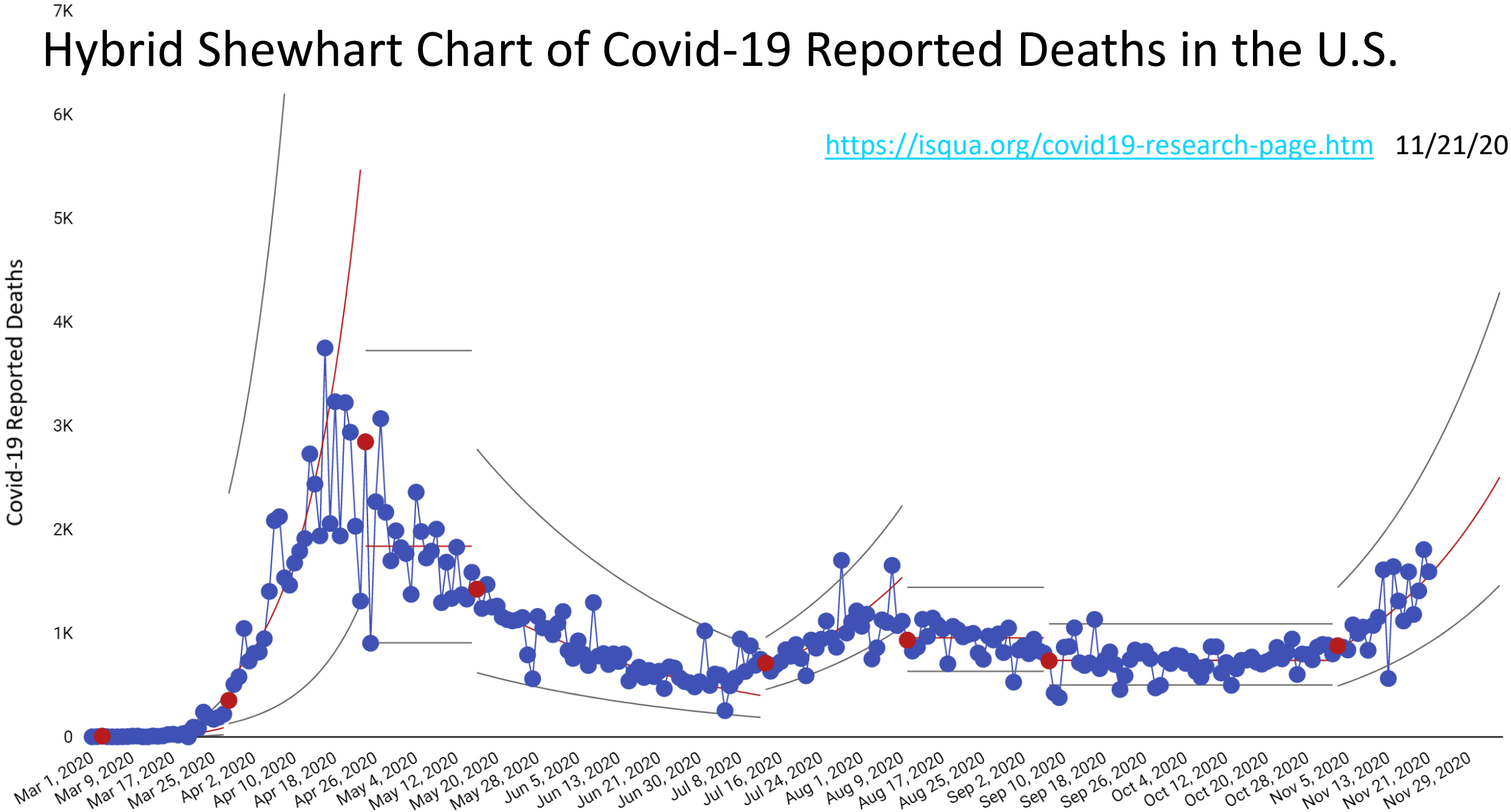
U.S.News & WORLD REPORT

Jan. 28, 2019

United States : Adjusted Daily Reported Covid-19 Deaths

Hybrid Shewhart Chart of Covid-19 Reported Deaths in the U.S.

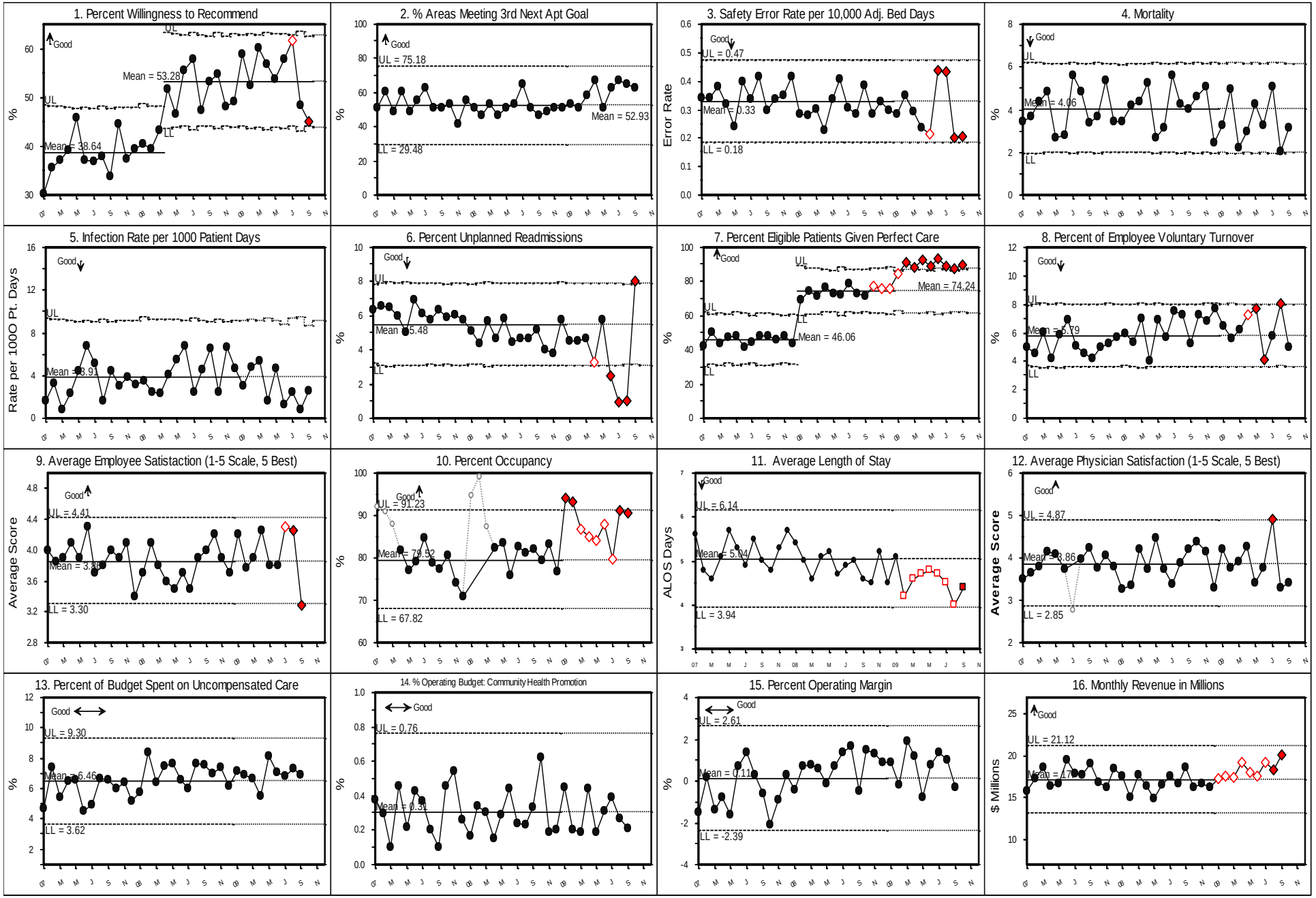
https://isqua.org/covid19-research-page.htm 11/21/20



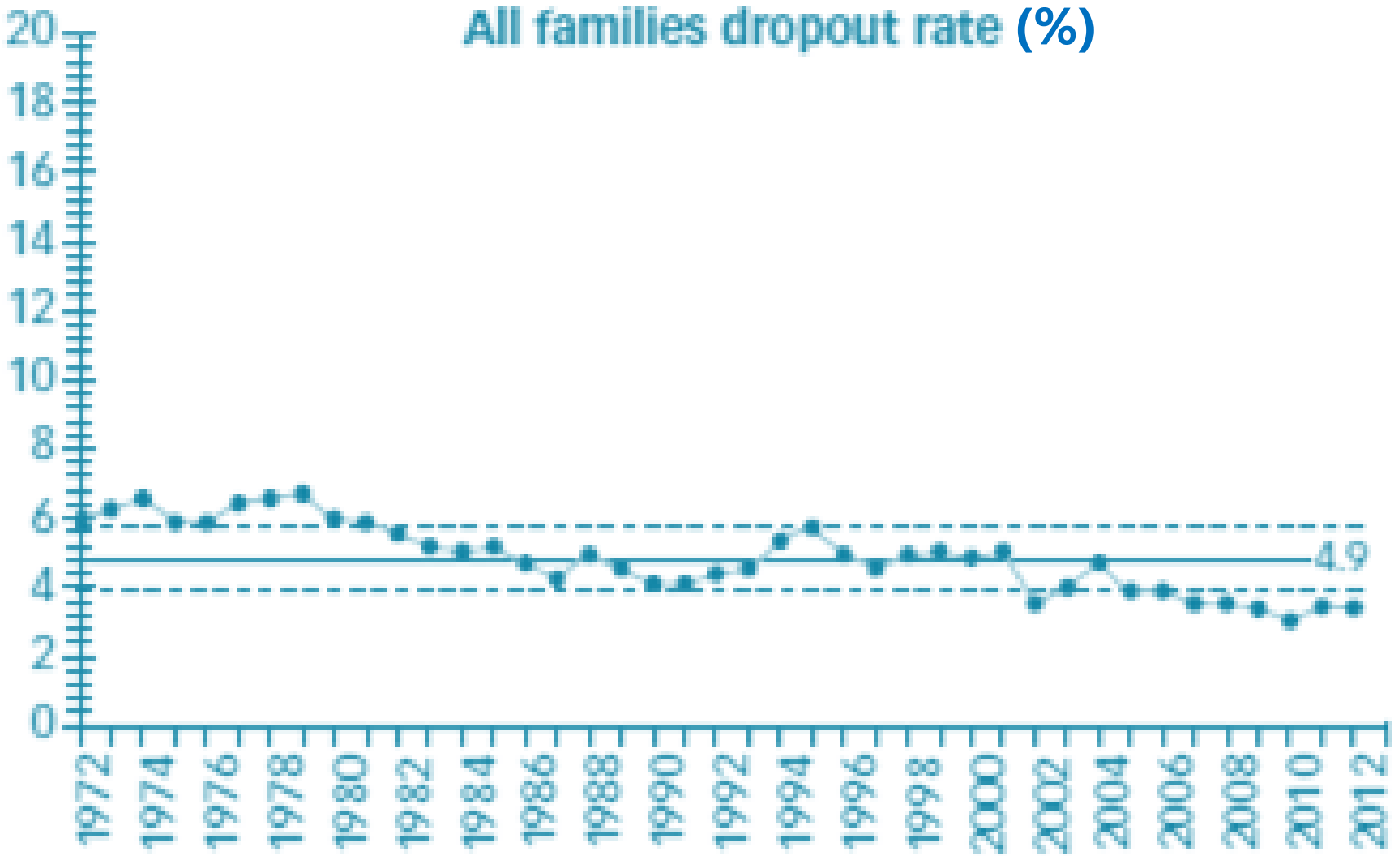
Vector of Measures for a Hospital

Appreciation of a System using Shewhart Charts

Study both the detailed and dynamic complexity in your organization



Shewhart charts of drop-out rates by family income

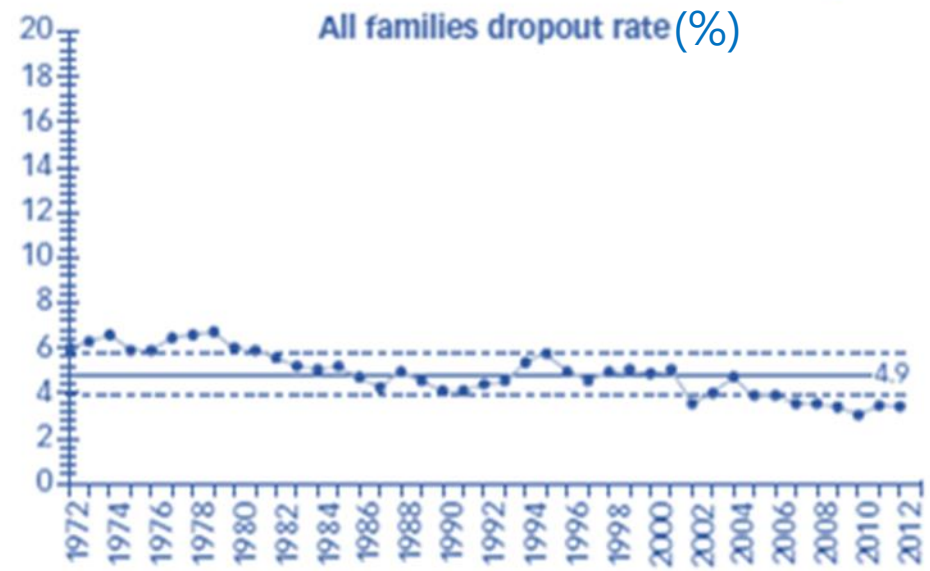


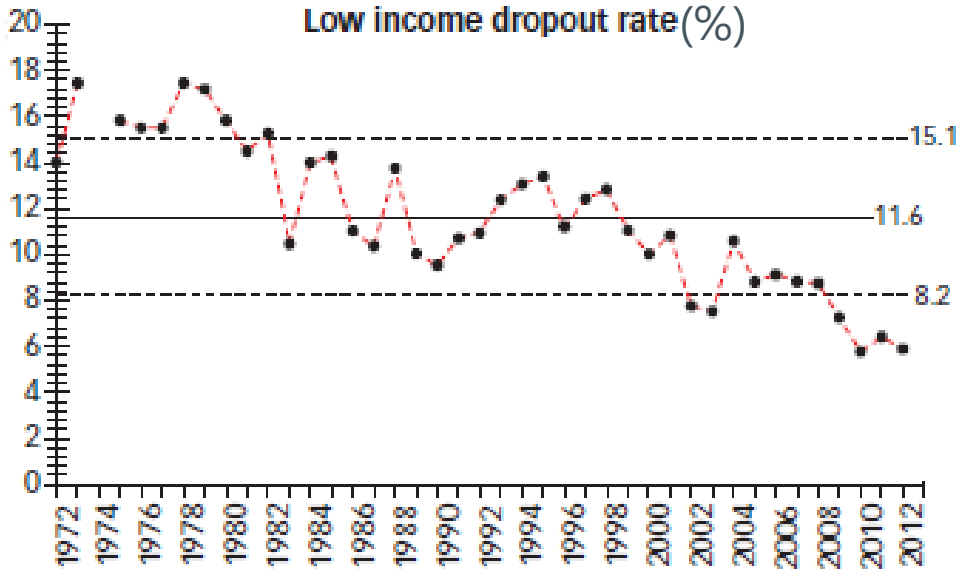
Understanding Variation 26 YEARS LATER

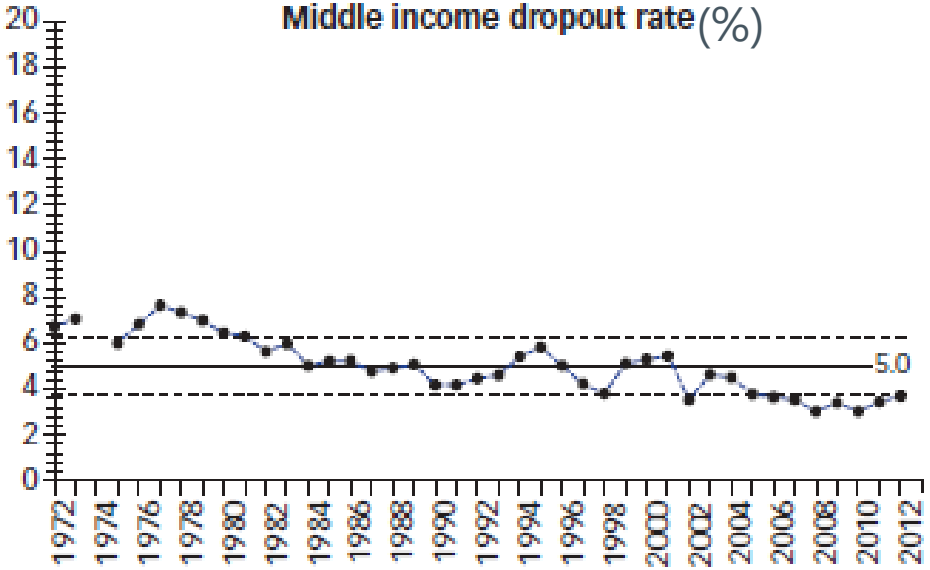
www.qualityprogress.com

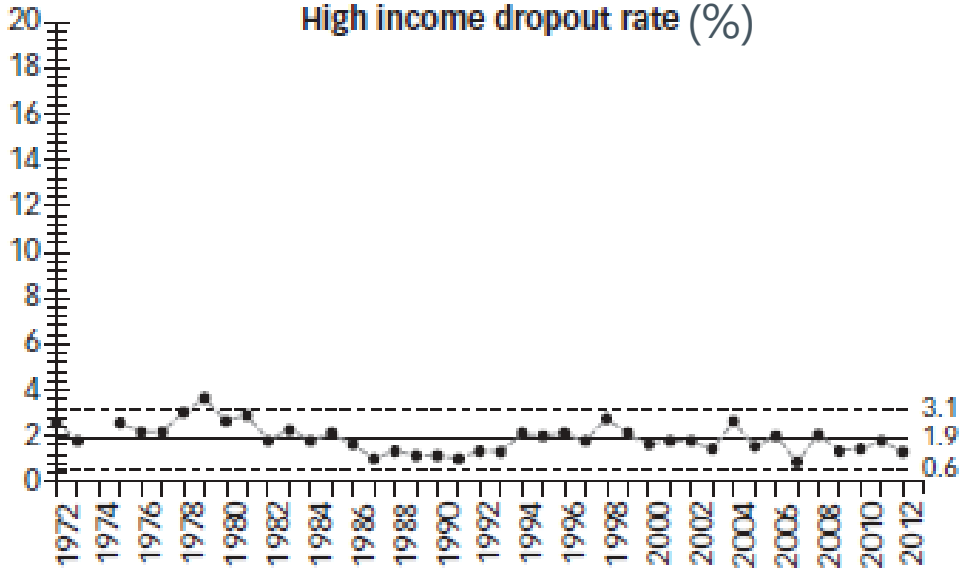
November 2016

Shewhart charts of drop-out rates by family income









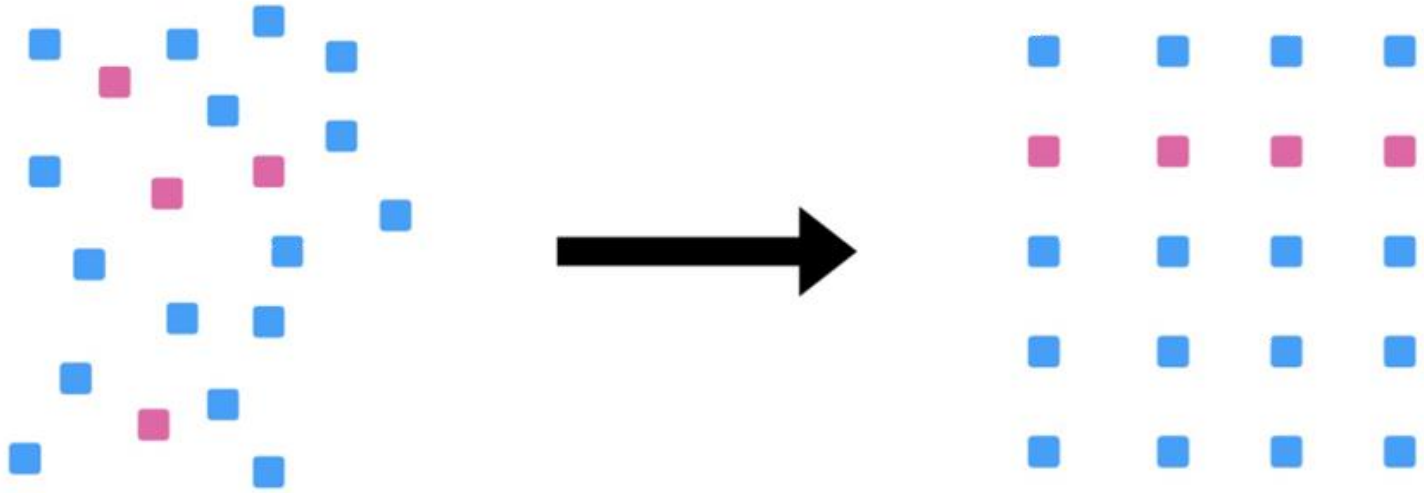
Understanding Variation 26 YEARS LATER

www.qualityprogress.com

November 2016

Rational Subgrouping

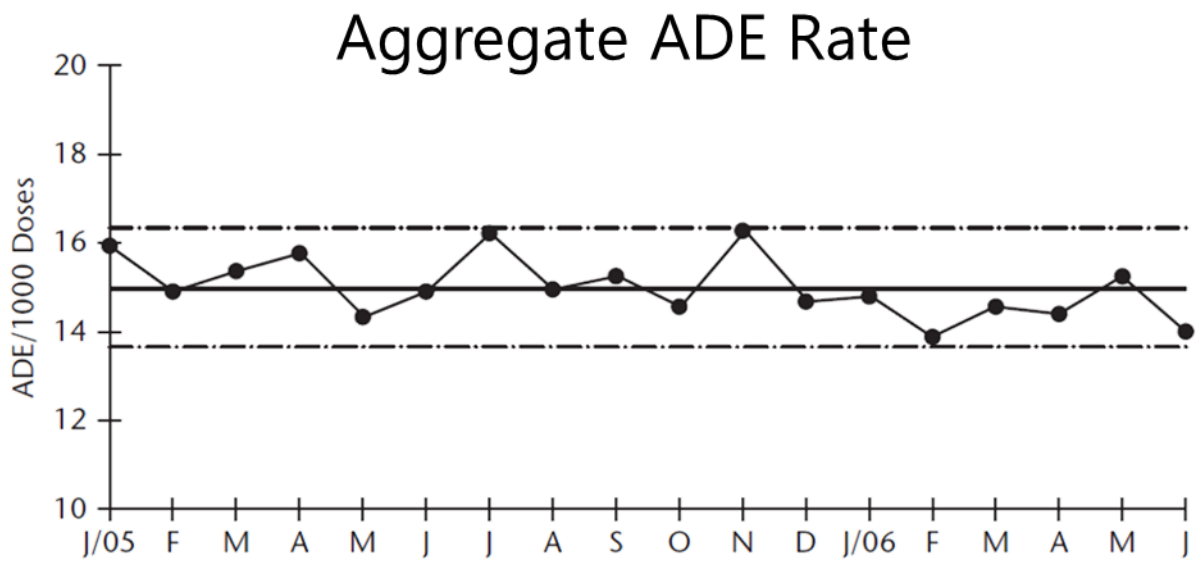
The concept of **subgrouping** is important in using Shewhart charts effectively to support improvement.



"Obviously, the ultimate object is not only to detect trouble but also to find it, and such discovery naturally involves classification. The engineer who is successful in dividing his data into rational subgroups based upon rational hypotheses is therefore inherently better off in the long run than the one who is not thus successful."

W. Shewhart, *The Economic Control of Quality of Manufactured Product,* p. 299

Rational Subgrouping with a U-chart

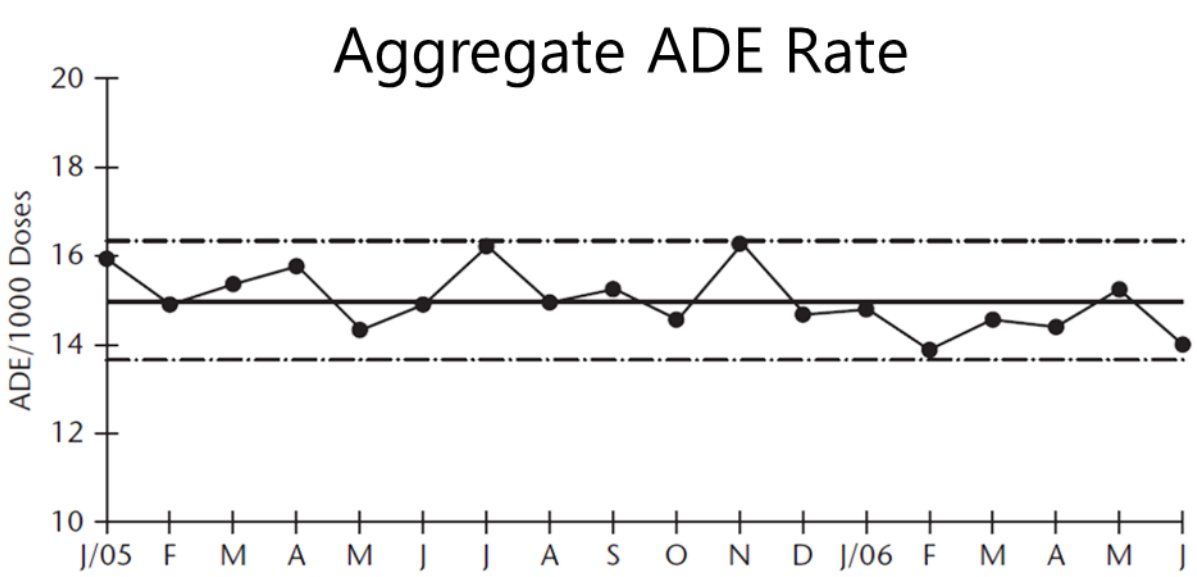


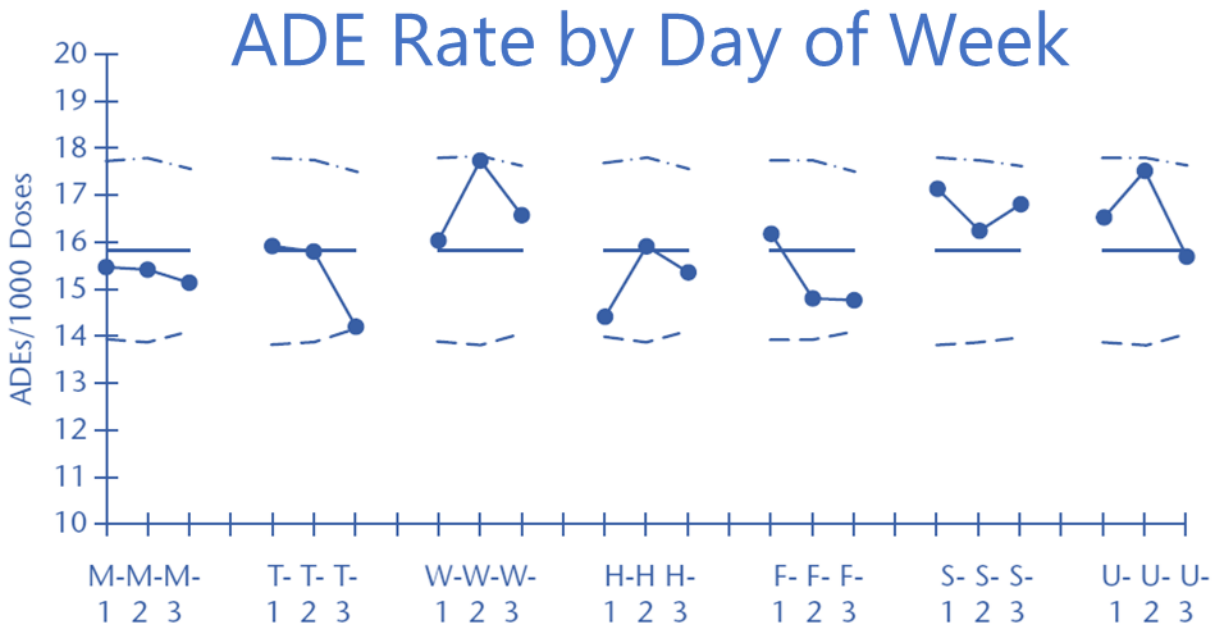
Subgrouping is to organize/ classify/ stratify data in a way that ensures the greatest chance for:

the greatest similarity among the data WITHIN each subgroup

and the greatest difference among the data ACROSS different subgroups.

Rational Subgrouping with a U-chart





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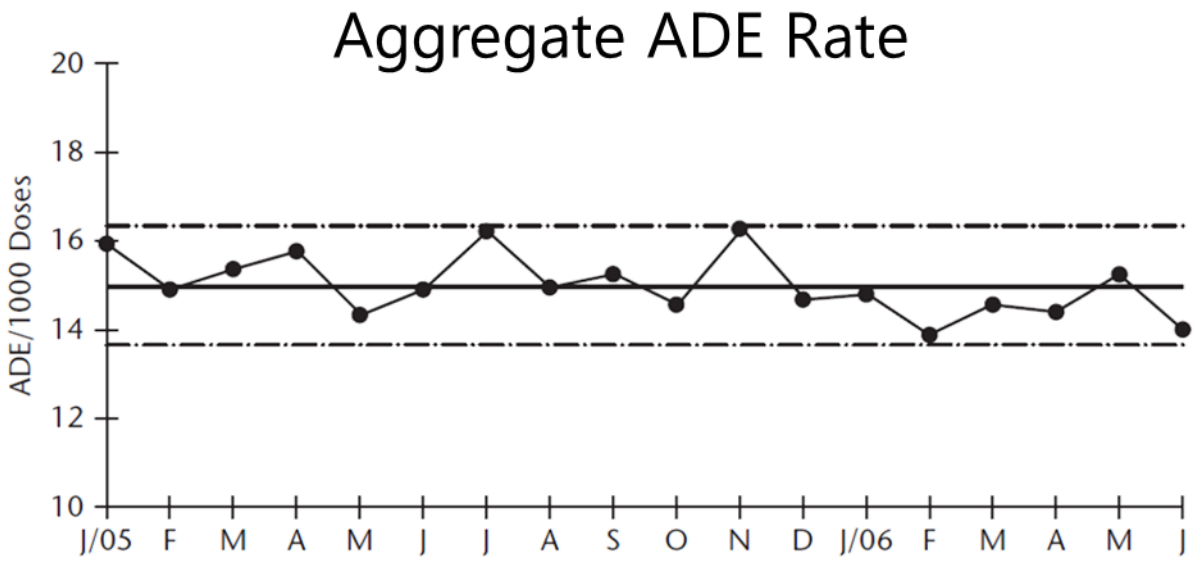

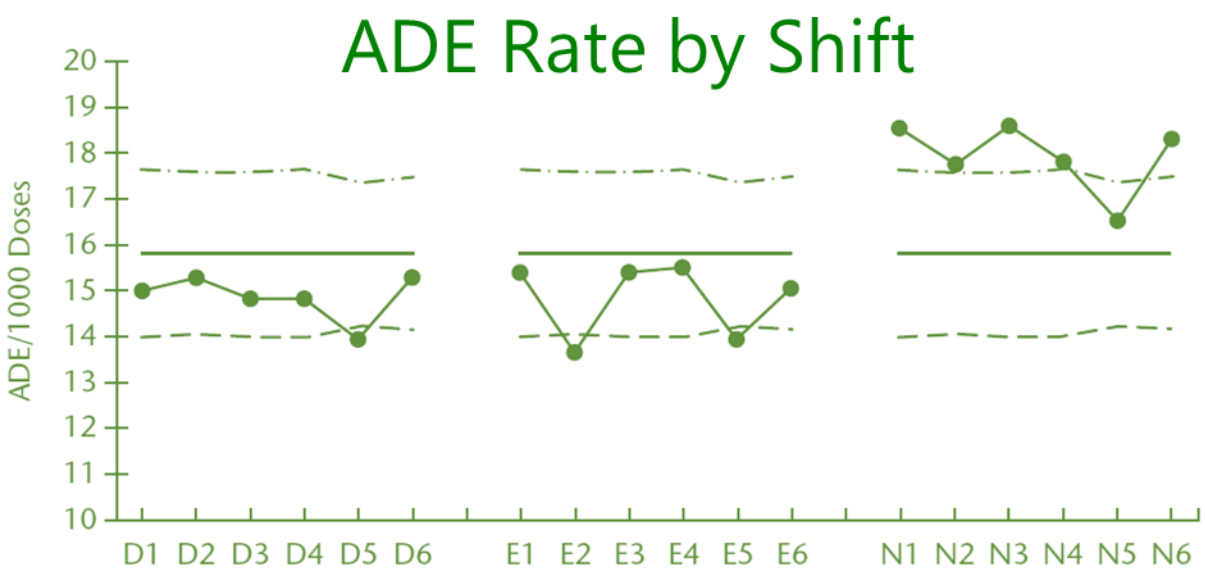

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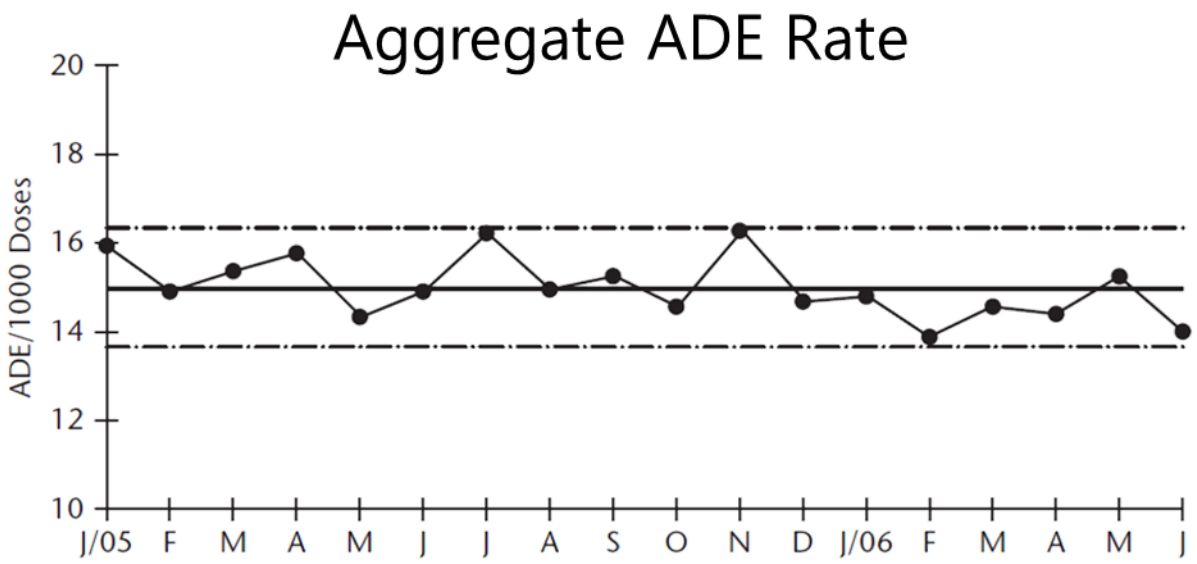

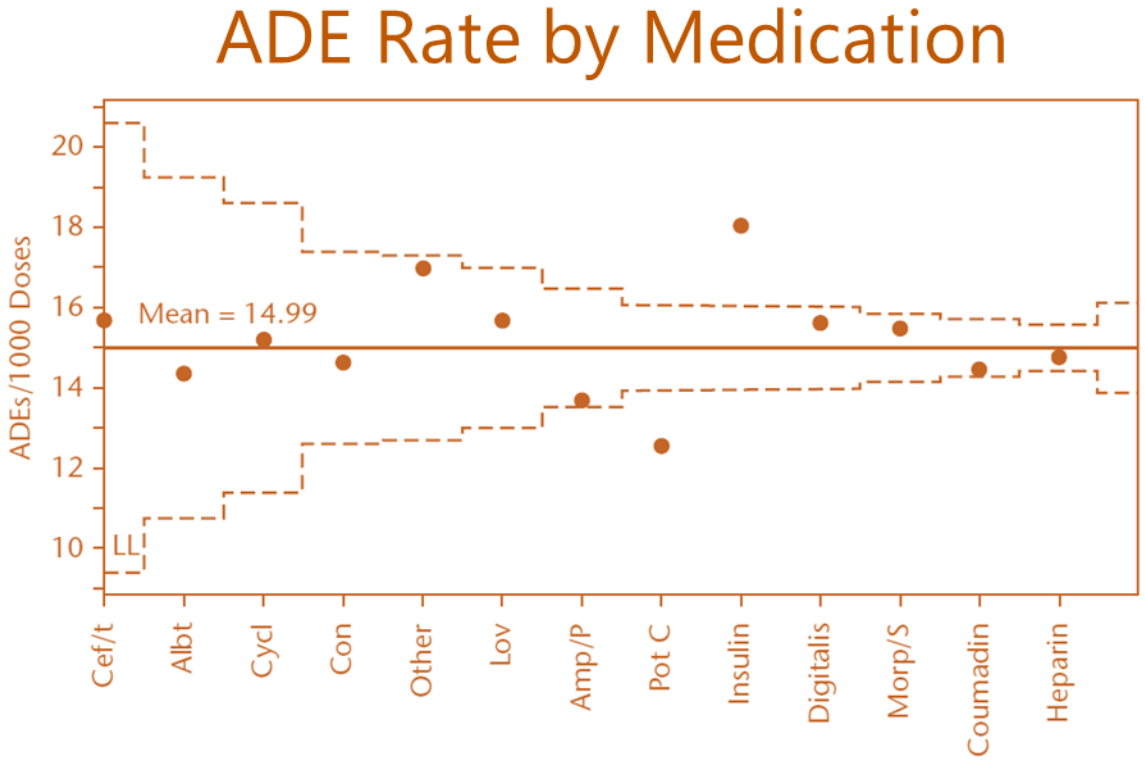

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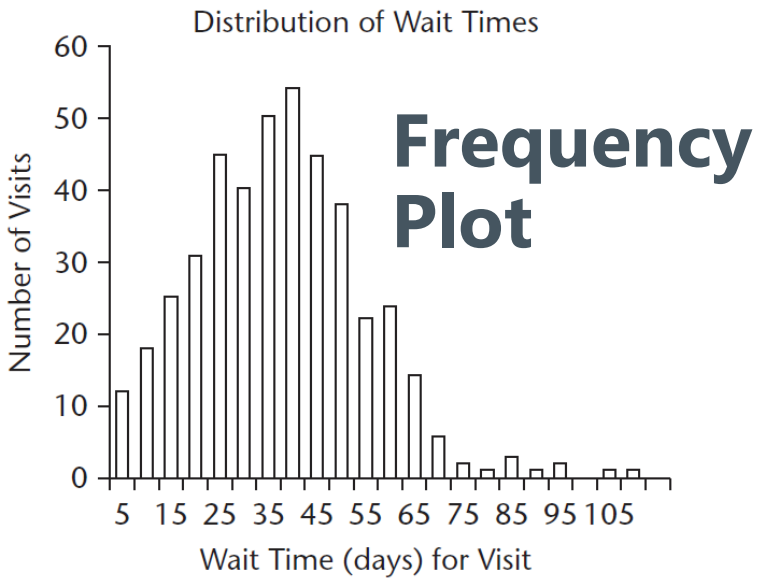
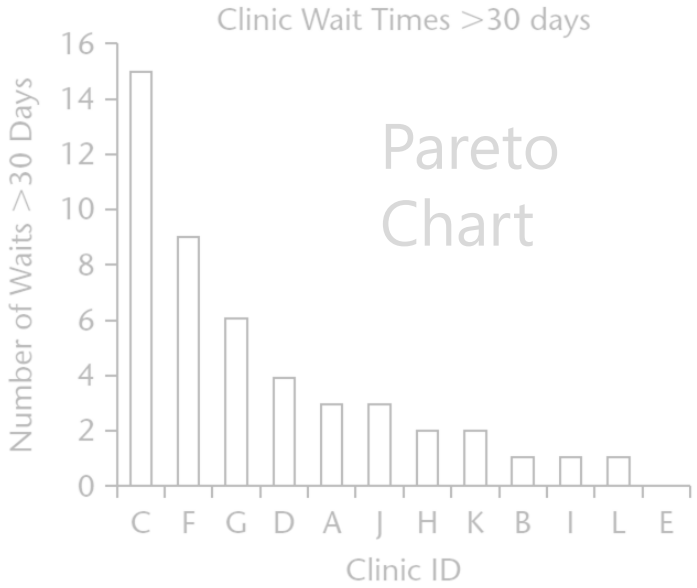
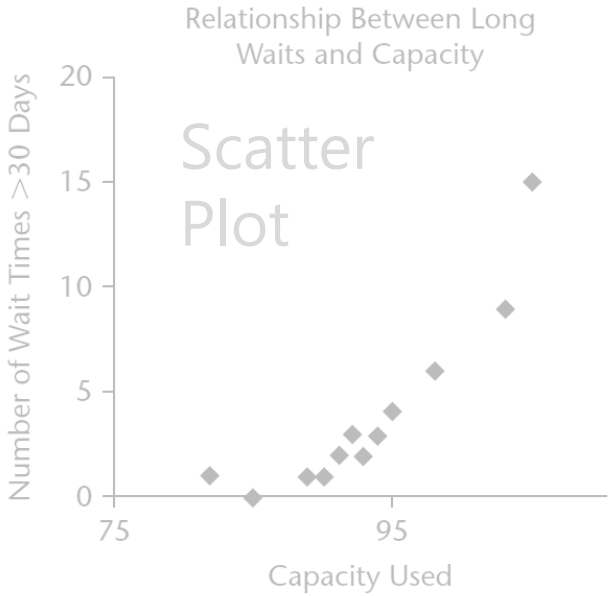
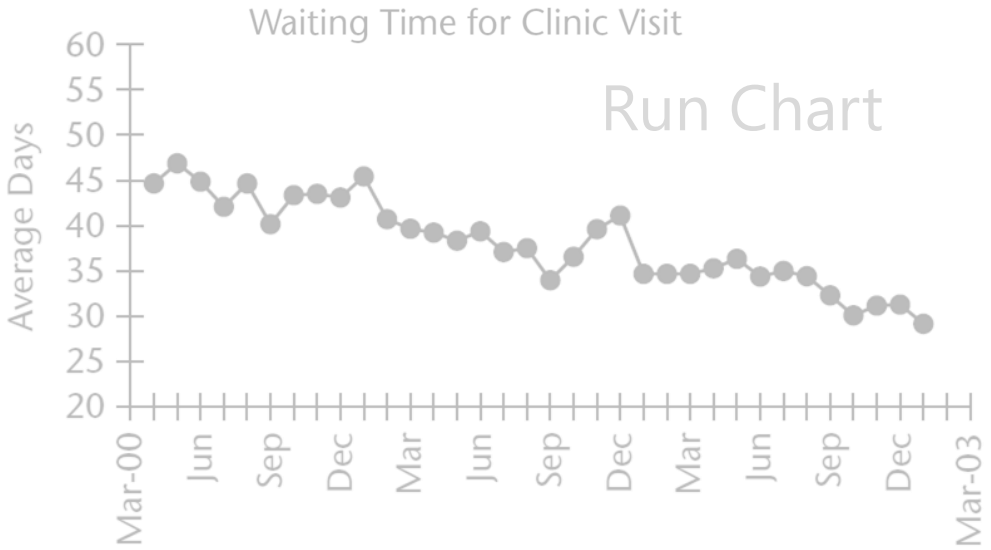
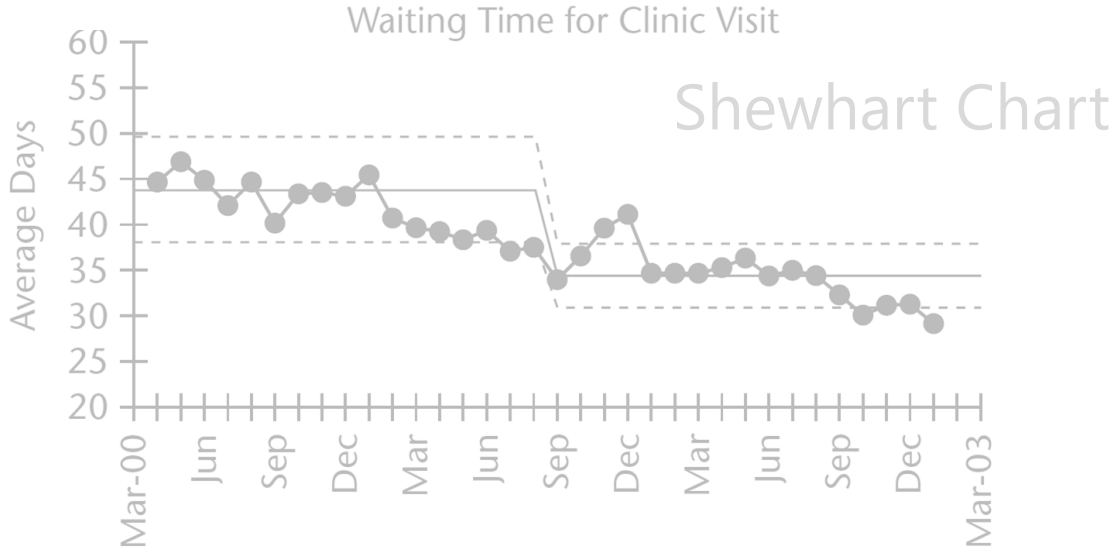
Five fundamental charts to visualize data for improvement











THE HEALTH CARE DATA GUIDE
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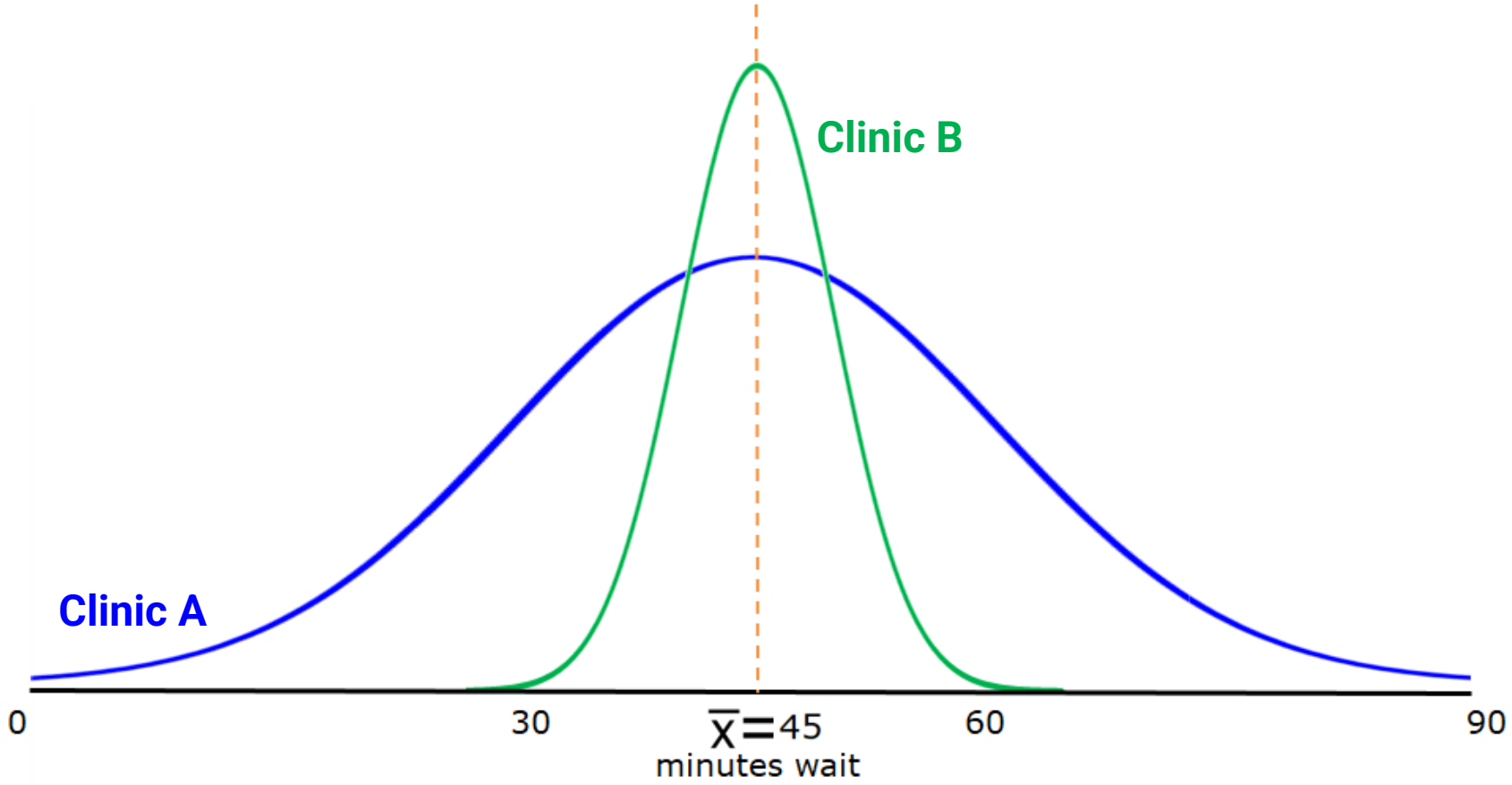
LLOYD P. PROVOST SANDRA K. MURRAY

Using frequency plots to make decisions

Choosing clinic A or B for your family

- both equal driving distance from home with free parking
- same satisfaction rating on Google
- Average wait time 45 minutes

Which do you choose?

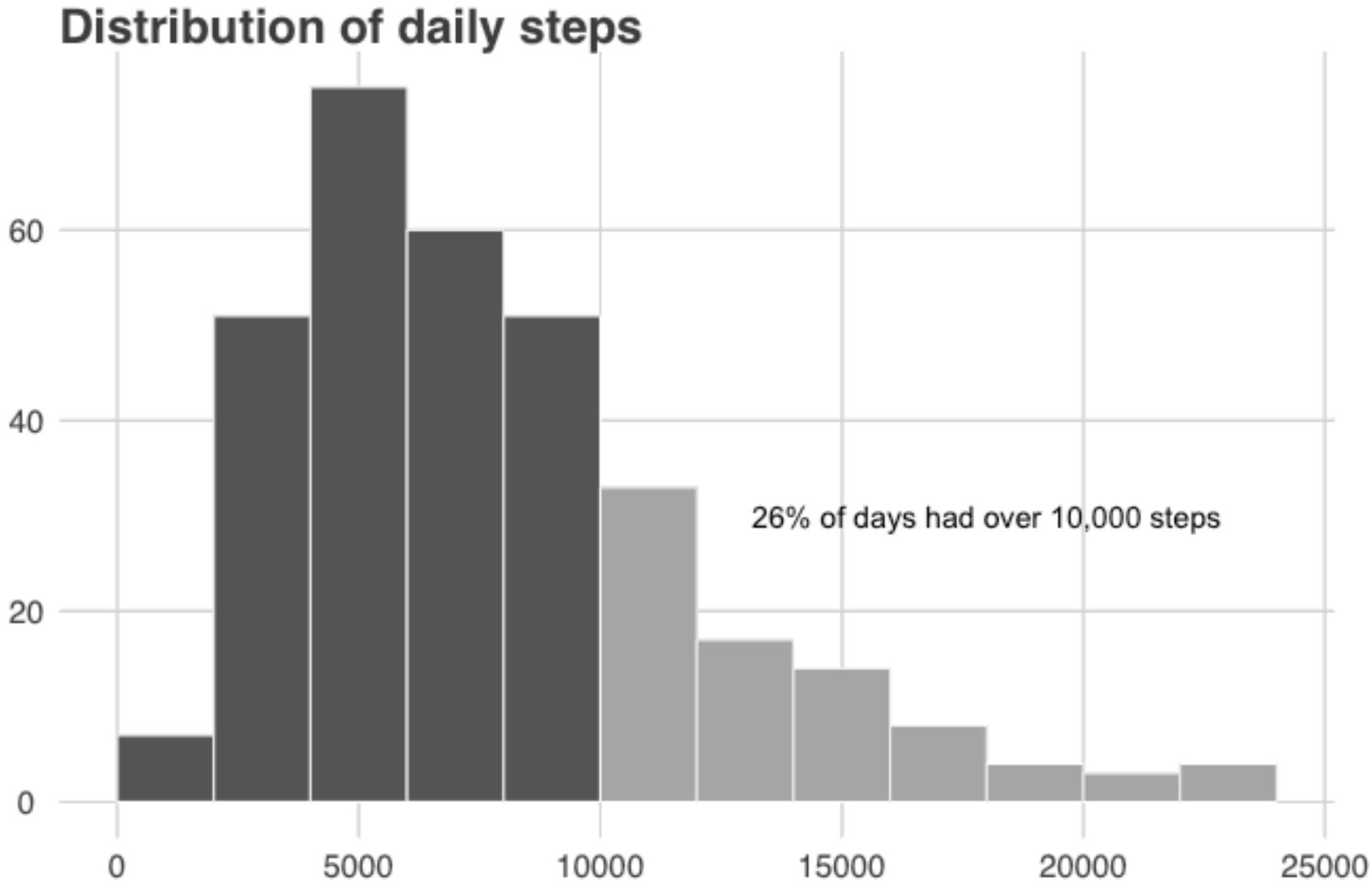


NOW which do you choose?

Frequency Plot

Show all the data; good for exploratory analysis.

Visualise the location, the spread, modality, and symmetry for the distribution of a numerical measure.

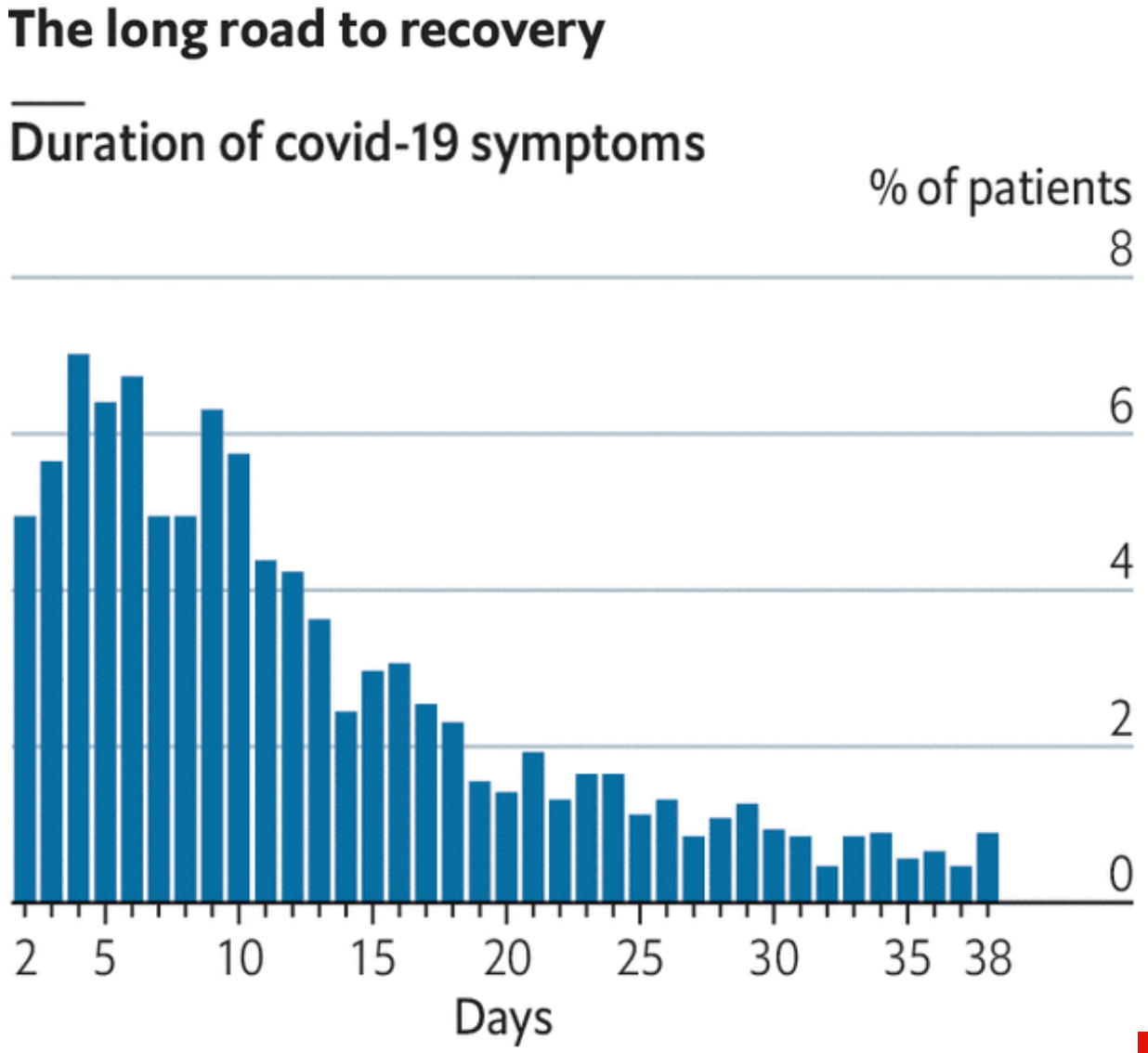


2014: A year in review with iPhone pedometer data Geoffrey Litt

Relative Frequency Plot

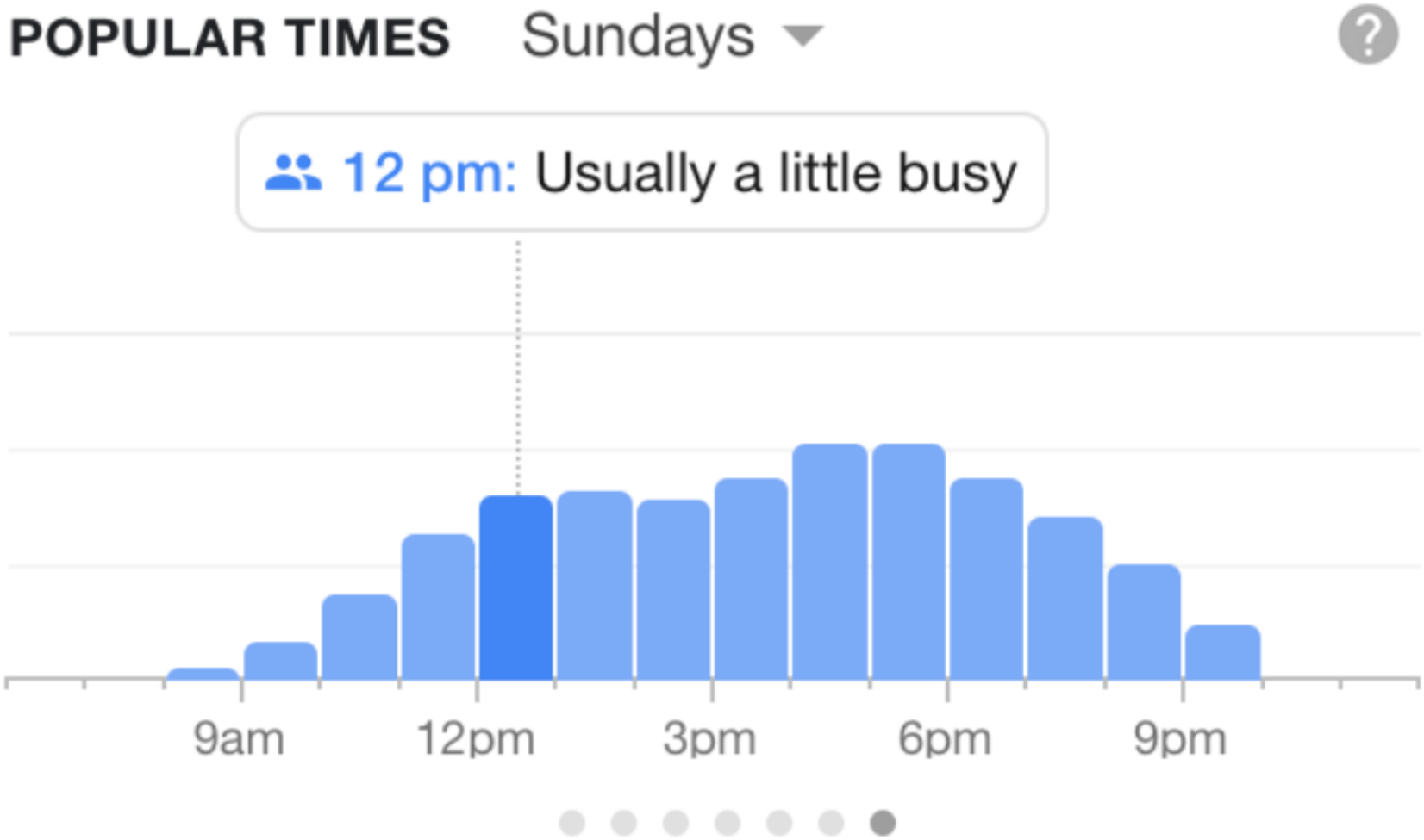
Displayed here are the *percentages* of observations that fall into each range rather than the counts

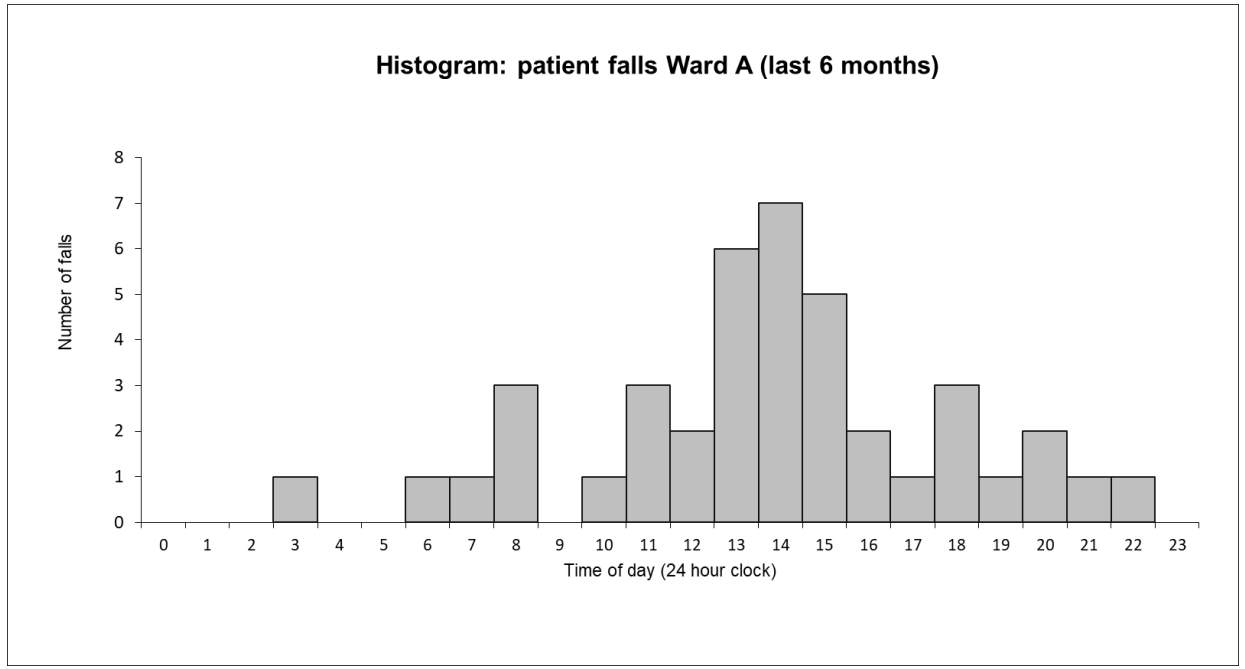
Whole set = 100%

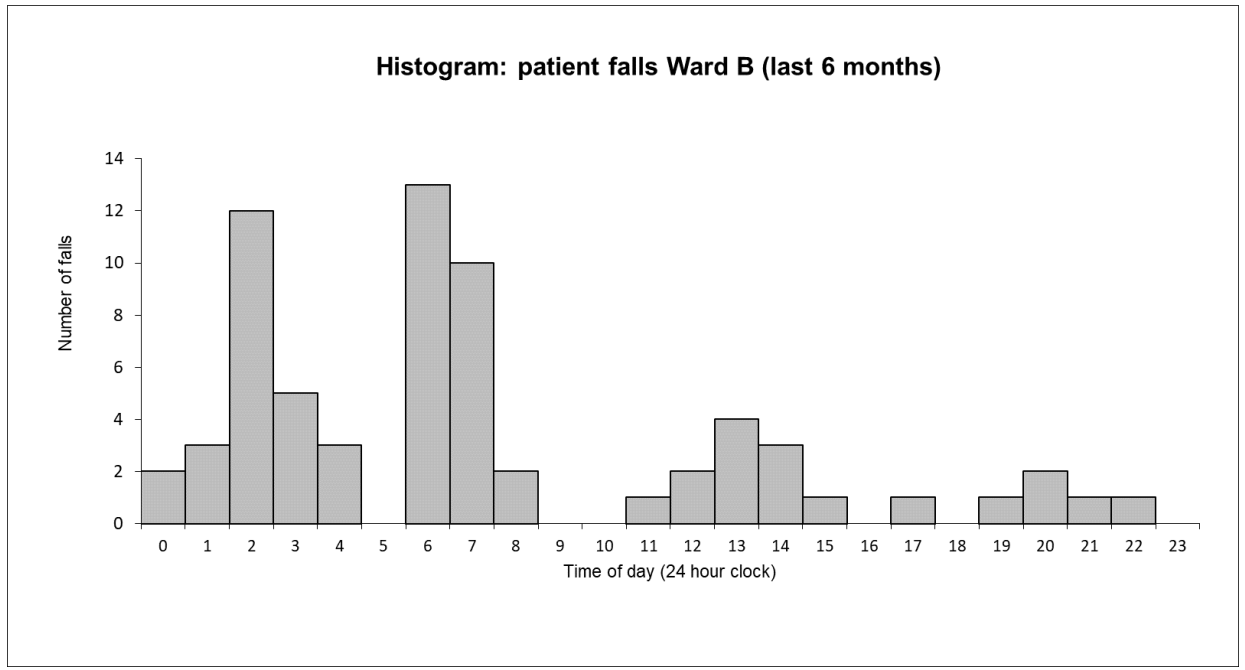


The Economist

Histograms in daily life

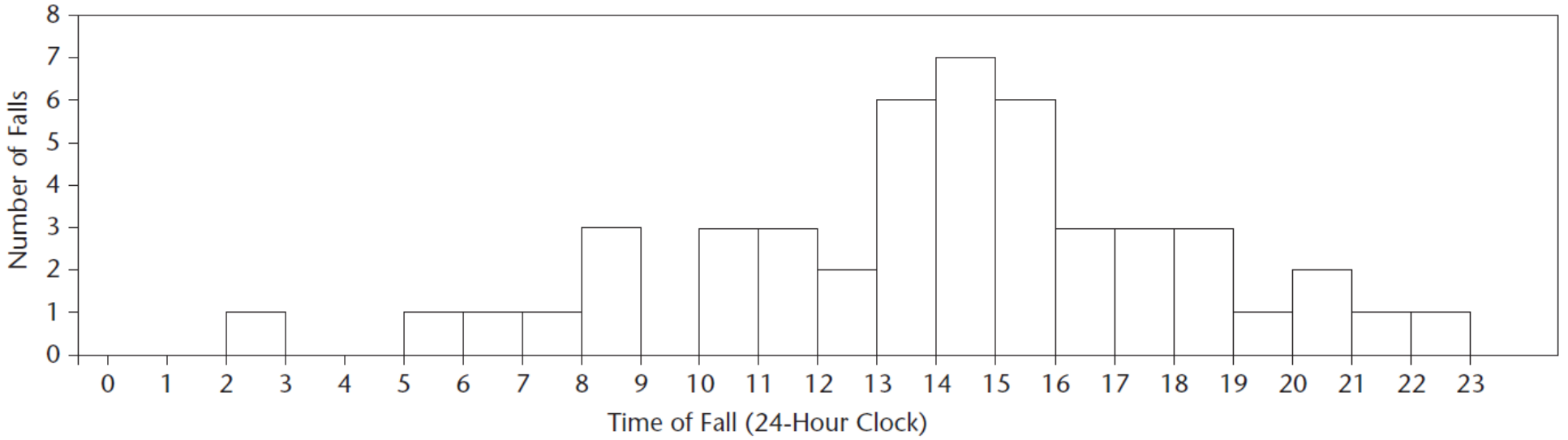



Histogram: patient falls Ward A (last 6 months)
Number of falls
0
1
2
3
4
5
6
7
8
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time of day (24 hour clock)

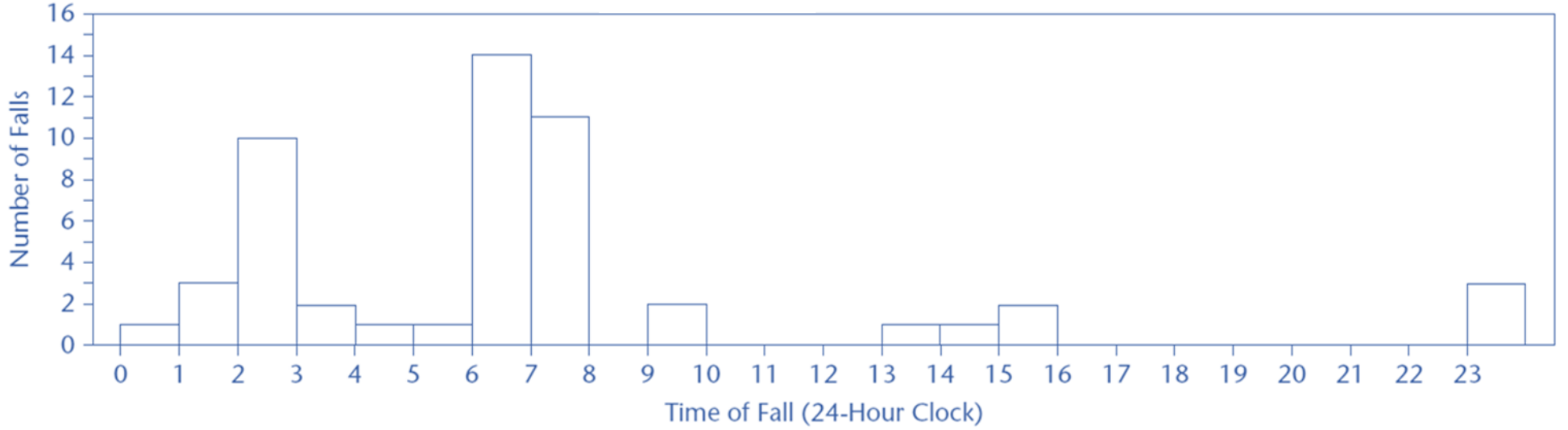

Histogram: patient falls Ward B (last 6 months)
Number of falls
0
2
4
6
8
10
12
14
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Time of day (24 hour clock)

Frequency Plot of patient falls by time of day **stratified by age** $(n = 100)$

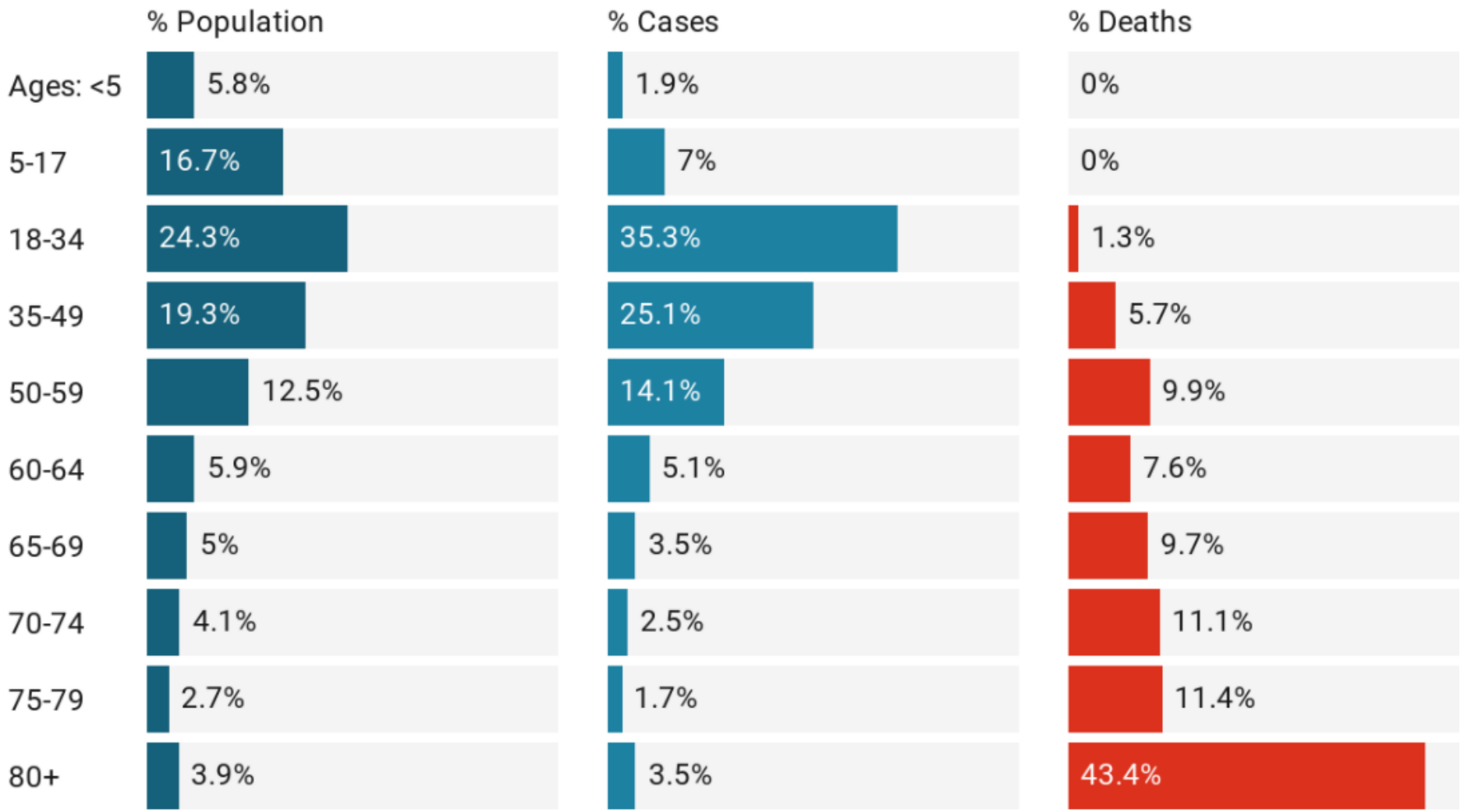
Age 50 and below



Age 51 and over



Frequency Plots: covid-19 outcomes by age group

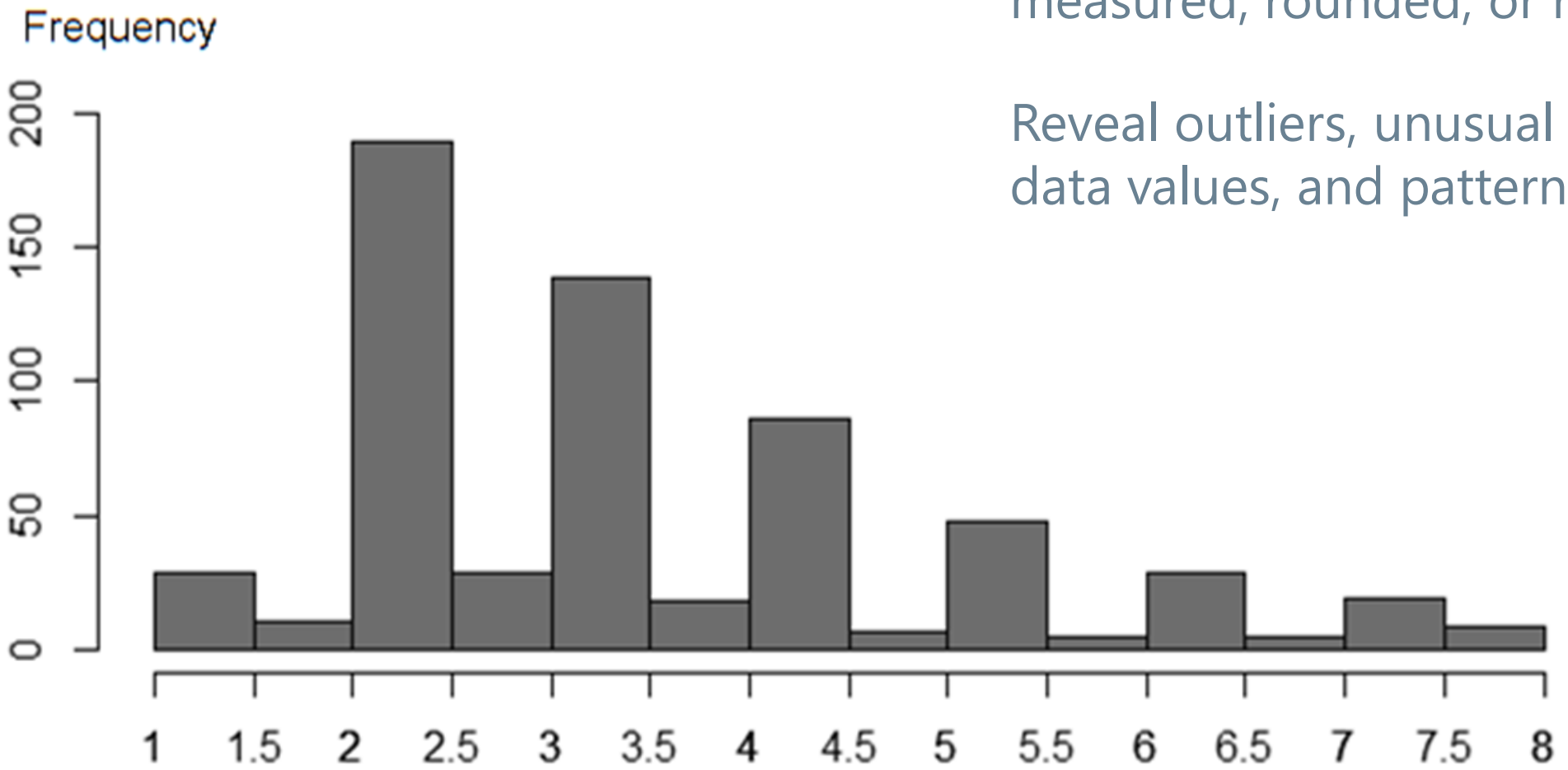


Based on cumulative totals as of July 27, 2020.

Chart: By: Harriet Blair Rowan - Bay Area News Group • Source: California Department of Public Health • Created with Datawrapper

Frequency Plot for length of stay in days

$(n = 700 \text{ patients})$



Gain insight into how data are measured, rounded, or recorded.

Reveal outliers, unusual data values, and patterns.

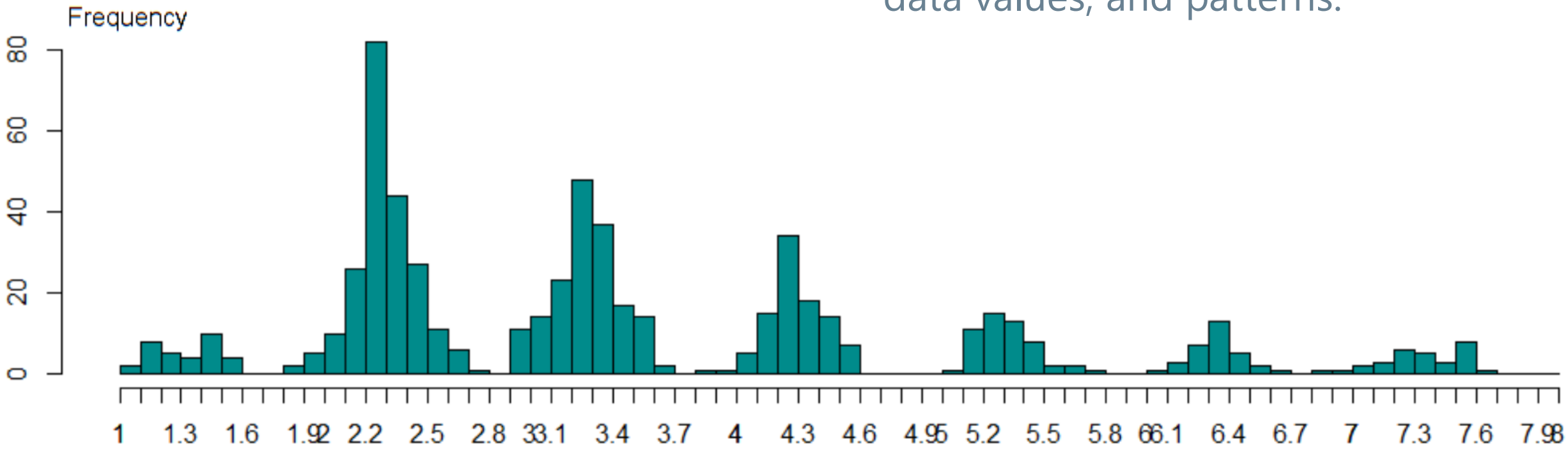
Frequency Plot for length of stay in days

$(n = 700 \text{ patients})$

Adjusting the measure and increasing the granularity of the *x*-axis bins reveals some interesting gaps.

Gain insight into how data are measured, rounded, or recorded.

Reveal outliers, unusual data values, and patterns.



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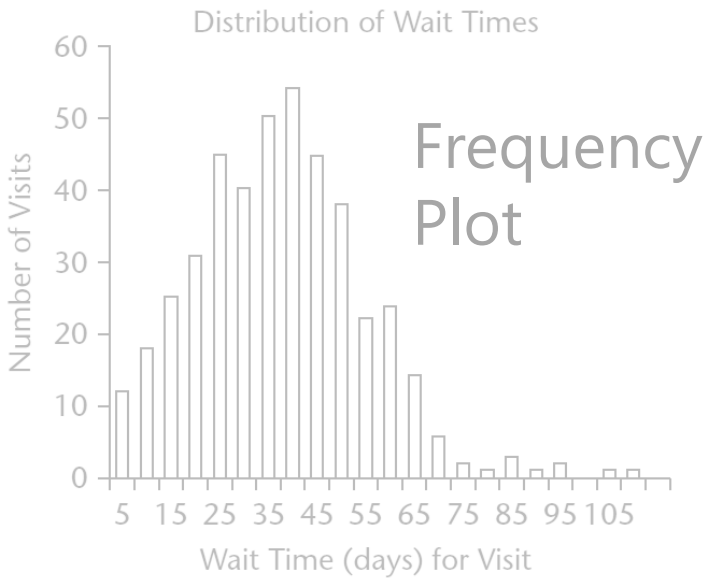

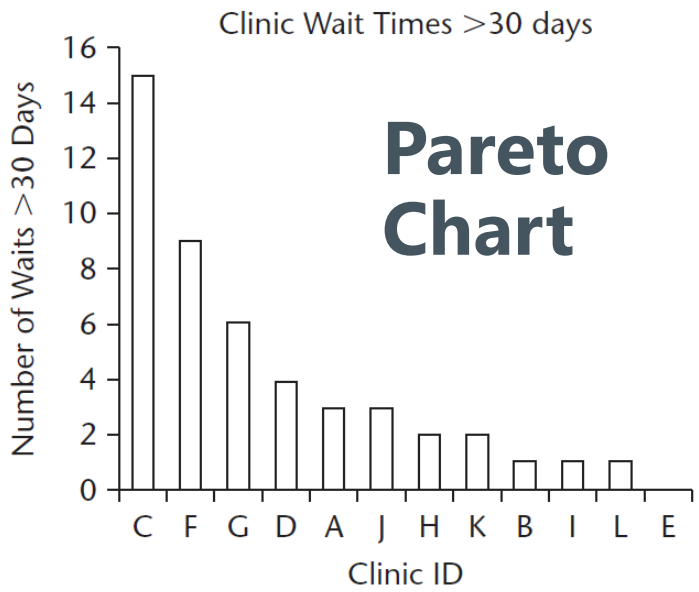

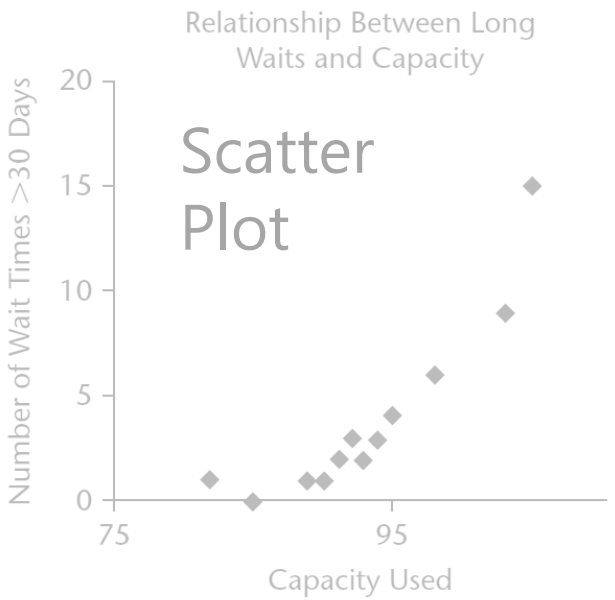

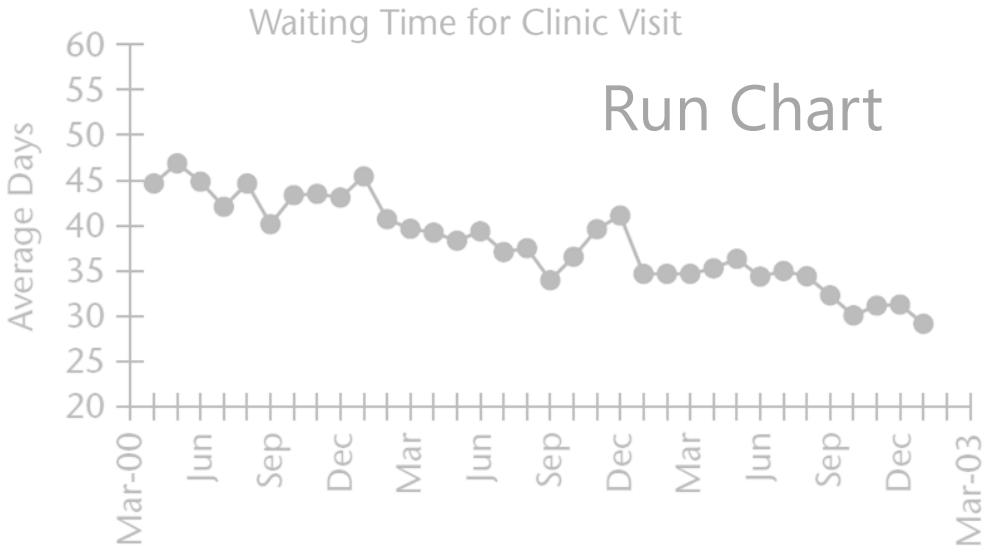

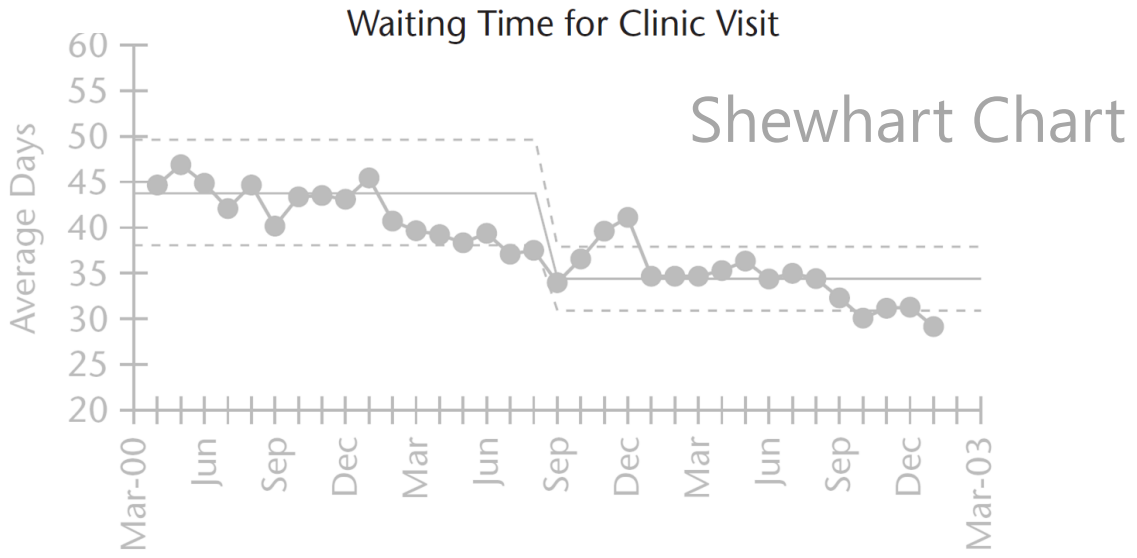

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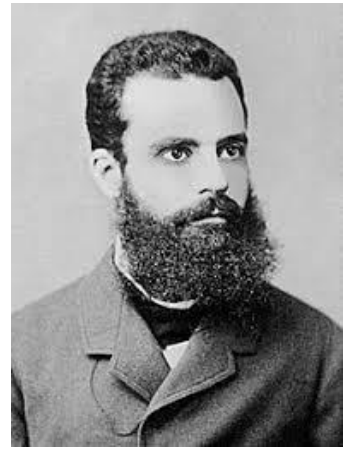
The Pareto Principle



Vilfredo Pareto (1848-1923)

Italian engineer, sociologist, economist, political scientist and philosopher

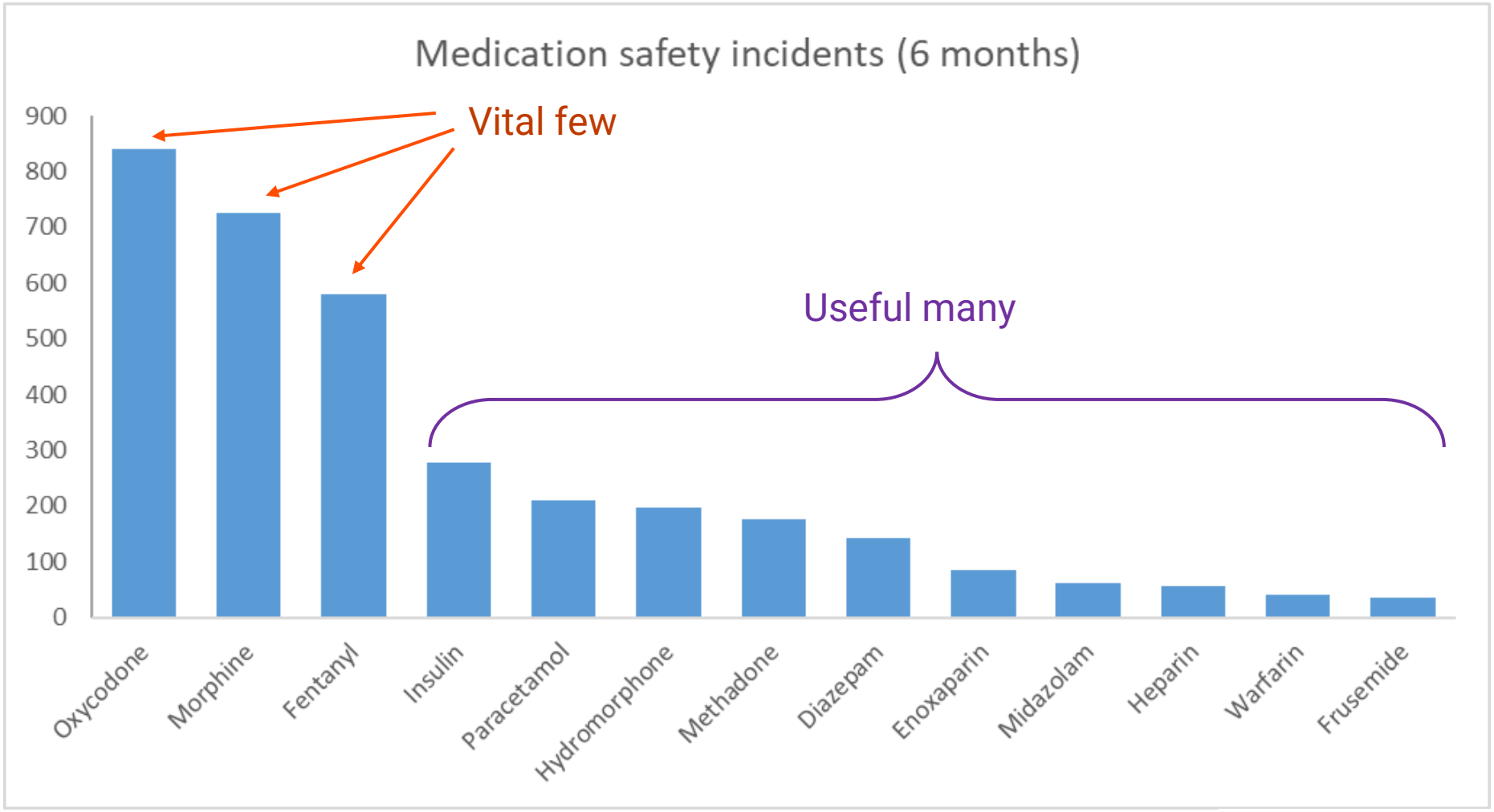
The Pareto principle (80/20):

- 80% of land in Italy owned by 20% of people
- Joseph Juran: 80% of the effects come from 20% of the causes

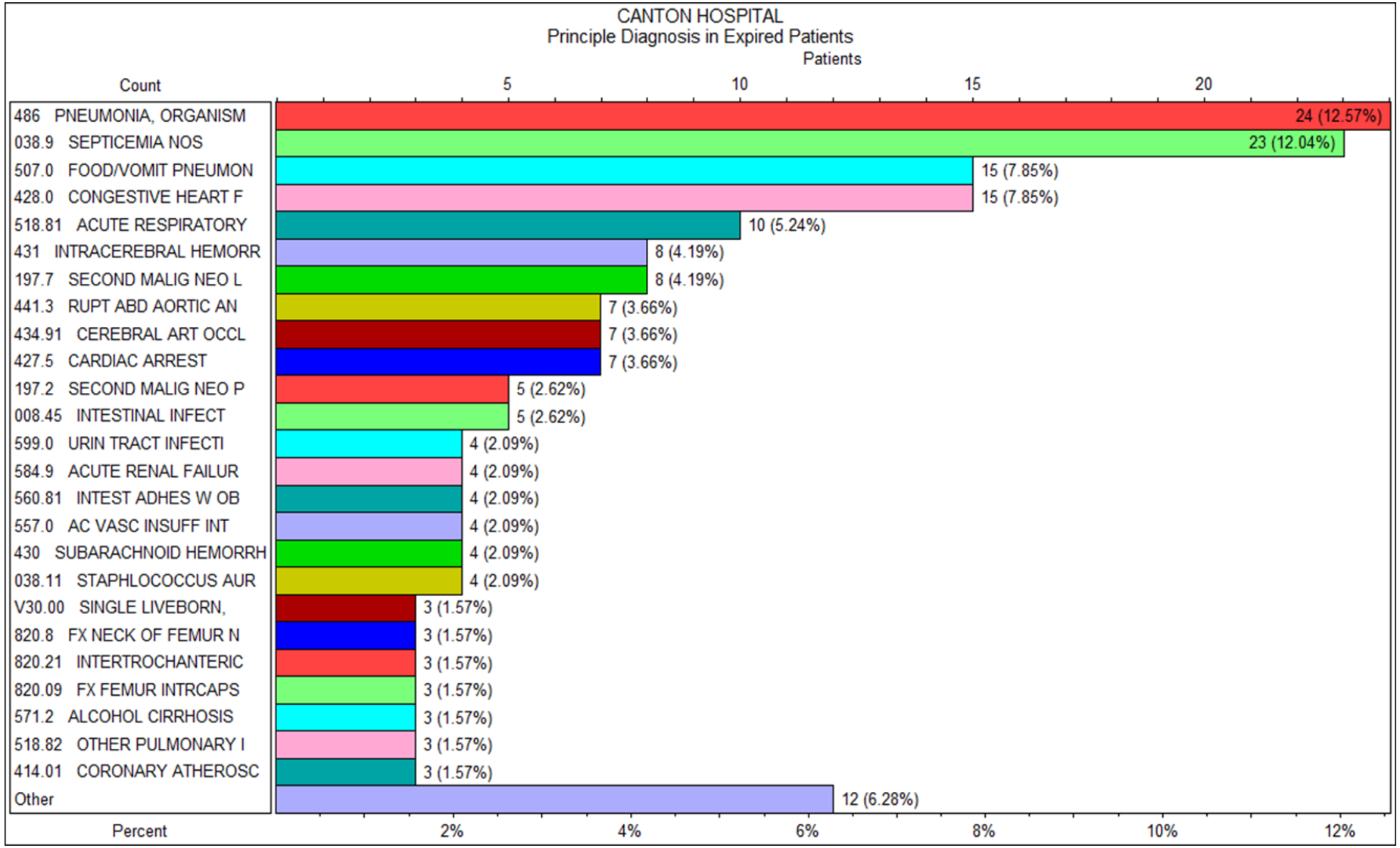
Pareto Chart

- Graphical display
- Elements contributing most to a problem: source of complaints, incidents of harm, etc (frequency)
- Relative contribution; focus for greatest impact
- Like a frequency plot for categorical data

BUSTER WAS CAUGHT BARKING UP THE WRONG TREE AGAIN.


Medication safety incidents (6 months)
Vital few
Useful many
900
800
700
600
500
400
300
200
100
0
Oxycodone
Morphine
Fentanyl
Insulin
Paracetamol
Hydromorphone
Methadone
Diazepam
Enoxaparin
Midazolam
Heparin
Warfarin
Frusemide

Pareto can be formatted many ways



Quality gaps identified through mortality review

BMJ Qual Saf 2016;**0**:1–9.

Daniel M Kobewka,[1,2] Carl van Walraven,[1,3] Jeffrey Turnbull,[4] James Worthington,[4] Lisa Calder,[5,6] Alan Forster[1,6]

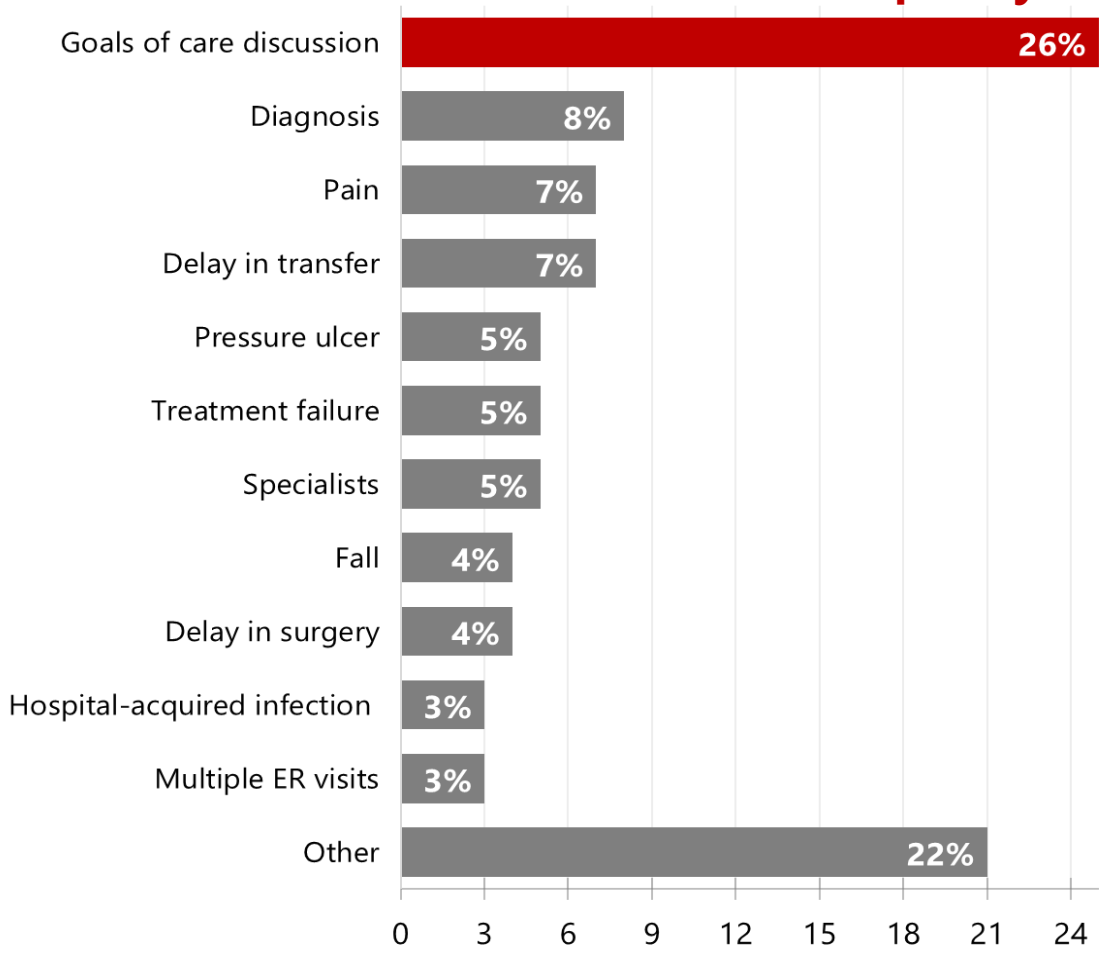
Table 3 Opportunities for improvement as classified by the corporate mortality-review committee

Opportunity for improvement	Number of occurrences N=97
Goals of care were not discussed or the discussion was inadequate	25
Delay in diagnosis or failure to achieve a diagnosis	8
Uncontrolled pain	7
Inappropriate delay in transfer to hospice or long-term care	7
Developed a pressure ulcer in hospital	5
Did not receive a treatment that was indicated	5
Appropriate specialists were not involved in the patient's care	5
Fall in hospital	4
Delay in surgery that affected patient's outcome and contributed to death	4
Hospital-acquired infection	3
Had multiple ER visits leading to admission and did not receive appropriate treatment	3
Complications of a procedure	2
Admission to hospital was unnecessary. There was no care given in hospital that the patient was not already receiving at their place of residence	2
Inadequate assessment and consideration of preoperative risk	2
Inadequate monitoring of an unstable patient	2
Error made during surgery	2
Other	11

A nice table with an important message.

Might that message not have been easier to discern and more compelling when displayed with a Pareto Chart?

Just over *one-quarter* of opportunities for improvement involved **goals of care that were not discussed adequately.**



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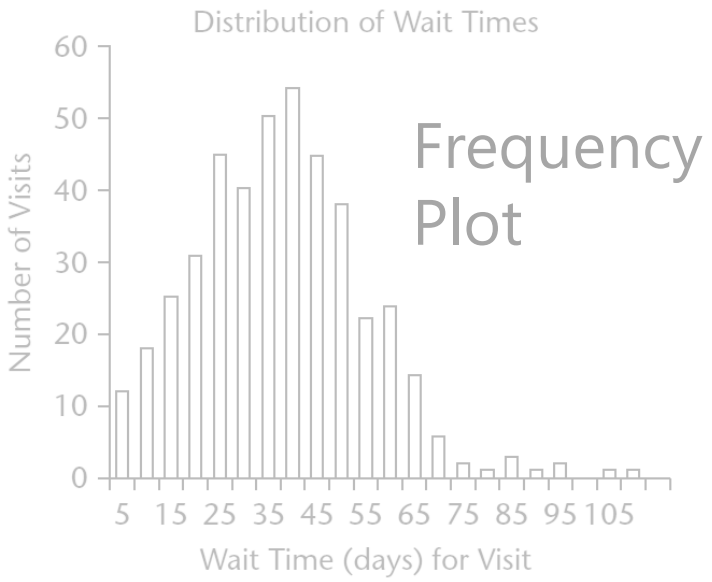

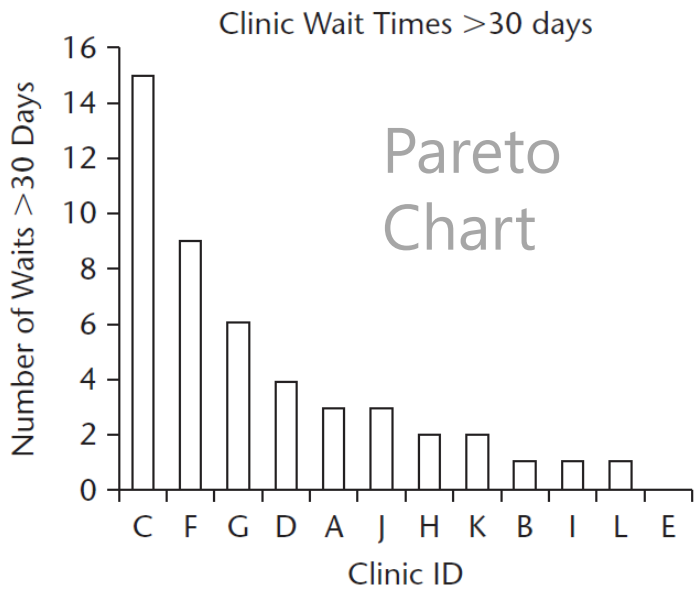

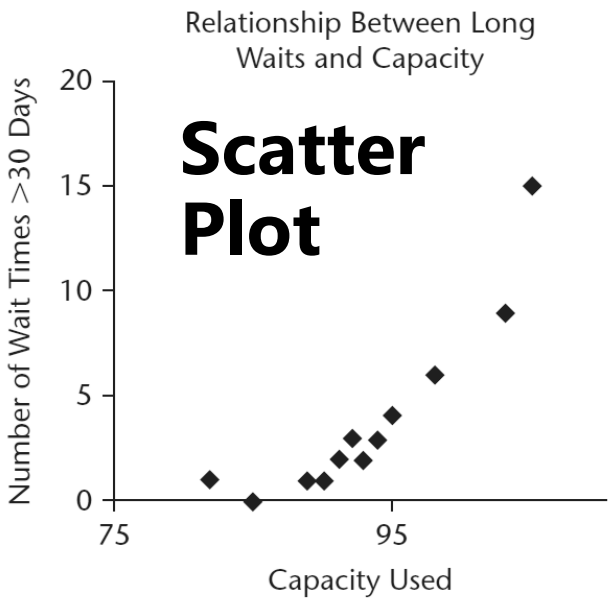

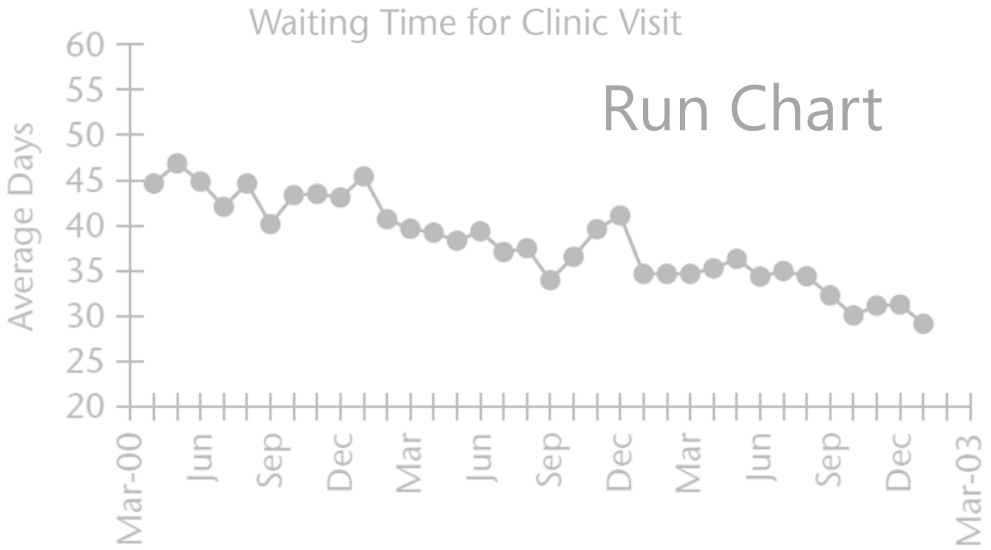

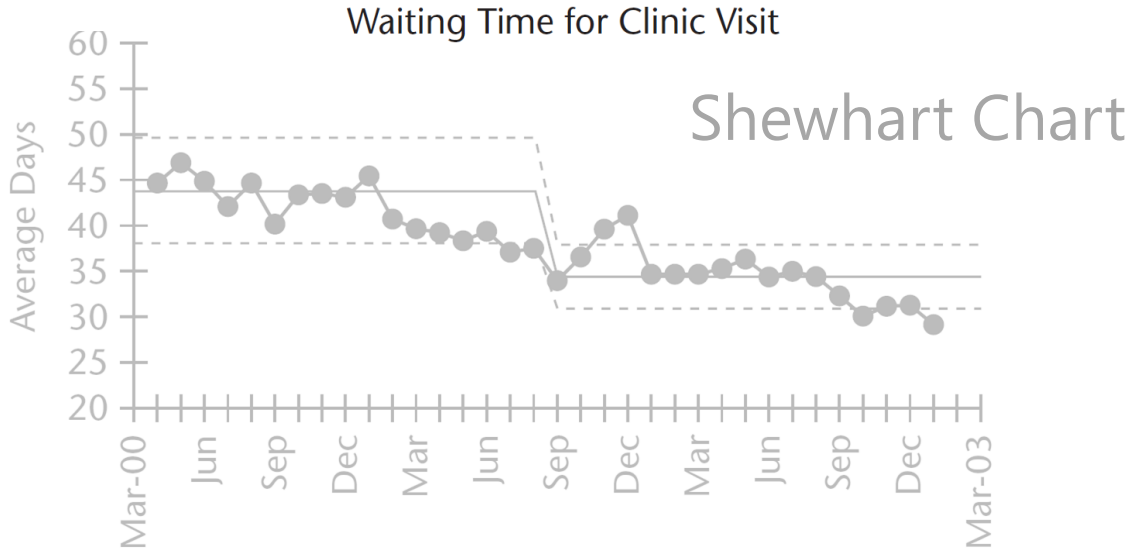

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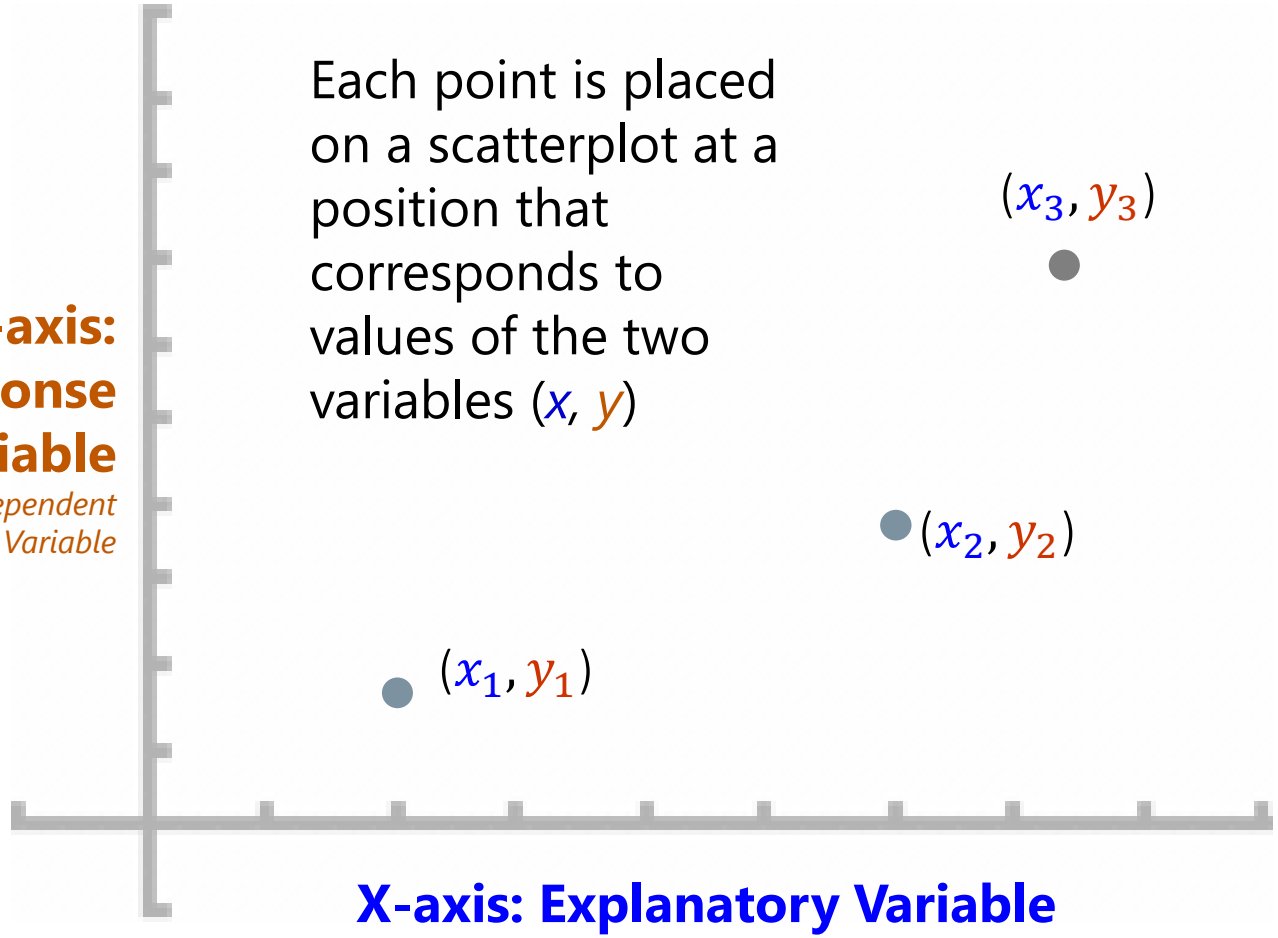
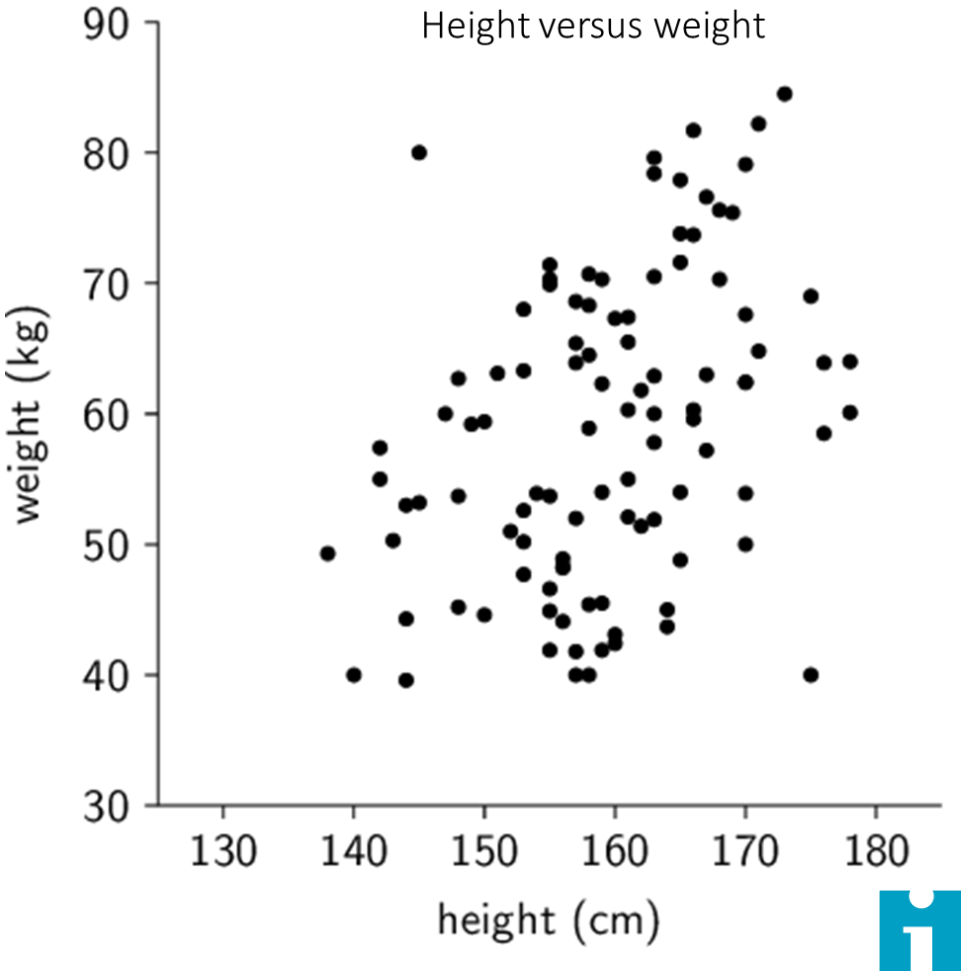
Scatter Plots

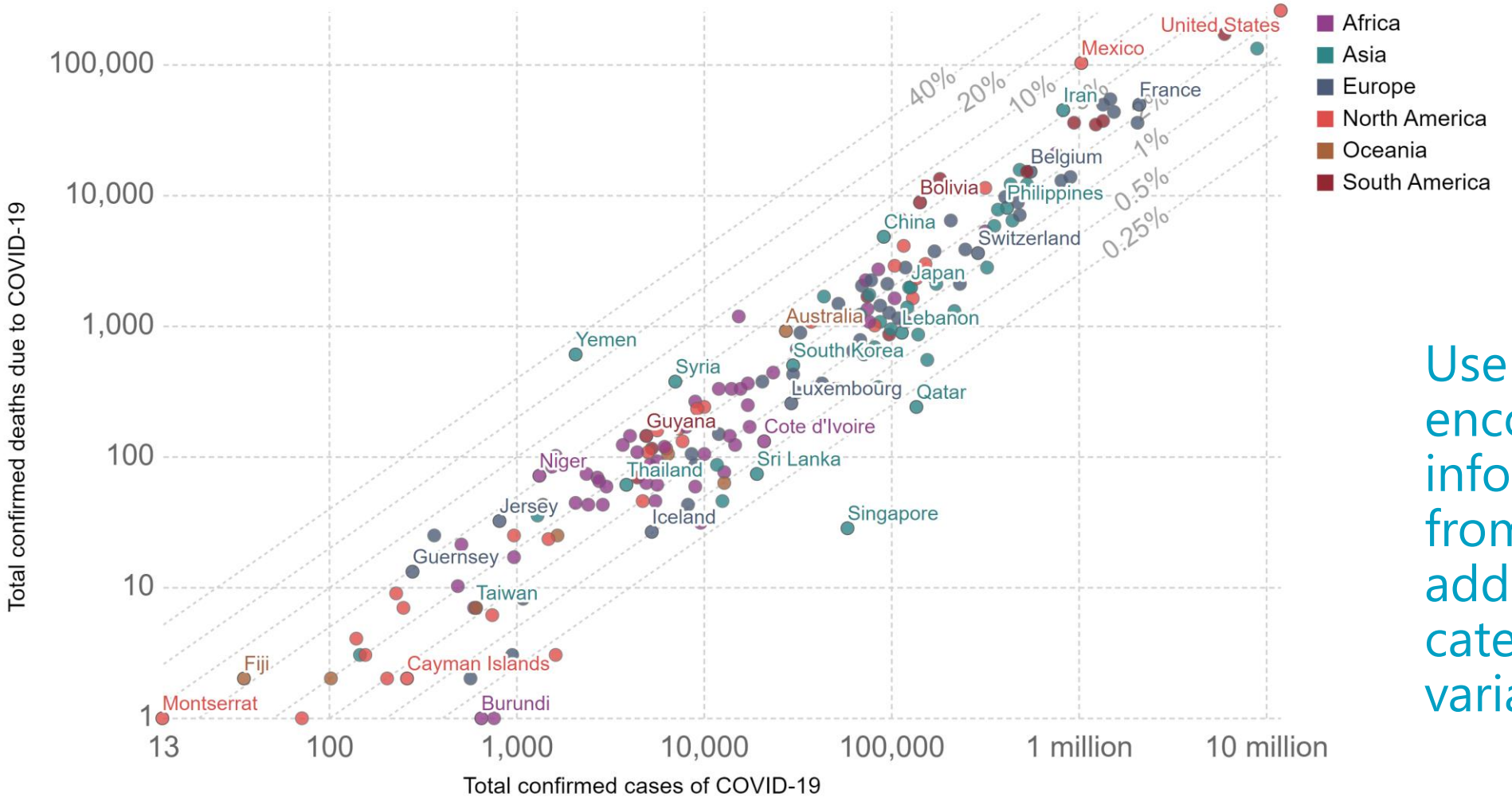
- Effective display for trends, patterns, and relationship for two variables
- Useful to look at relationships between outcome and process measures
- Understand special cause signals on Shewhart Charts





Total confirmed COVID-19 deaths vs. cases, Nov 21, 2020

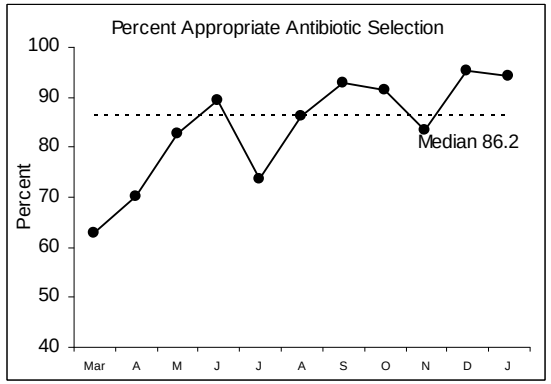
The number of confirmed cases is lower than the number of total cases. The main reason for this is limited testing. The grey lines show the corresponding case fatality rates, CFR (the ratio between confirmed deaths and confirmed cases).

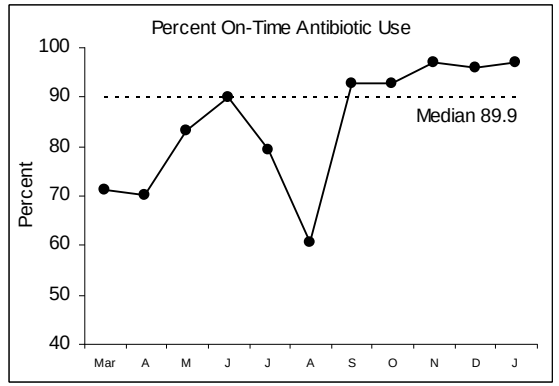


Use color to encode information from an additional categorical variable.

Source: European CDC – Situation Update Worldwide – Last updated 21 November, 10:06 (London time), Our World In Data
OurWorldInData.org/coronavirus • CC BY

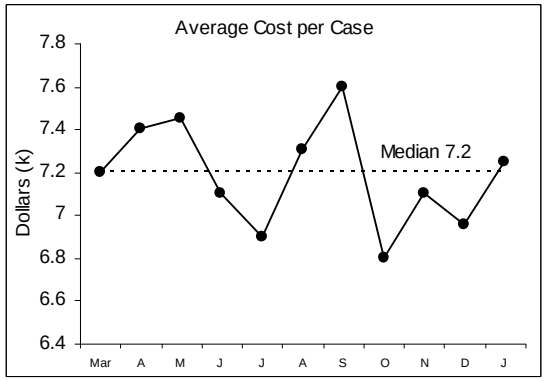
Process Measure





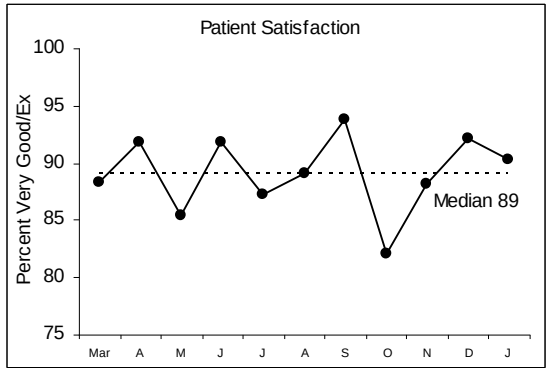
Process Measure

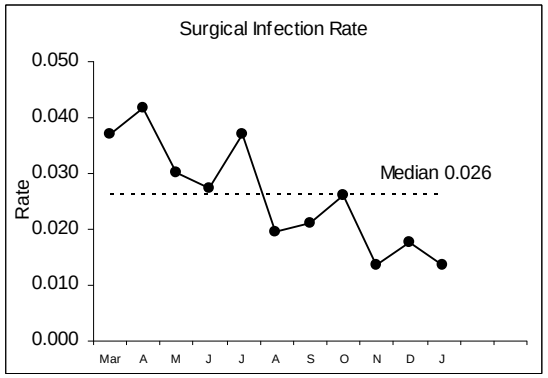
Process Measure



Balancing Measure

Balancing Measure



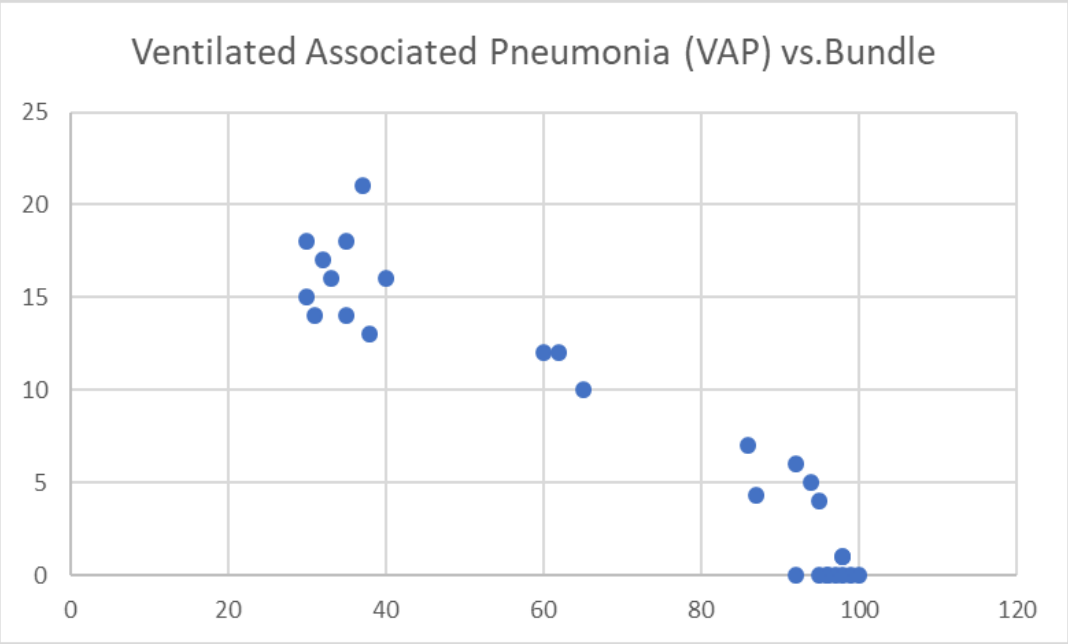


Outcome Measure

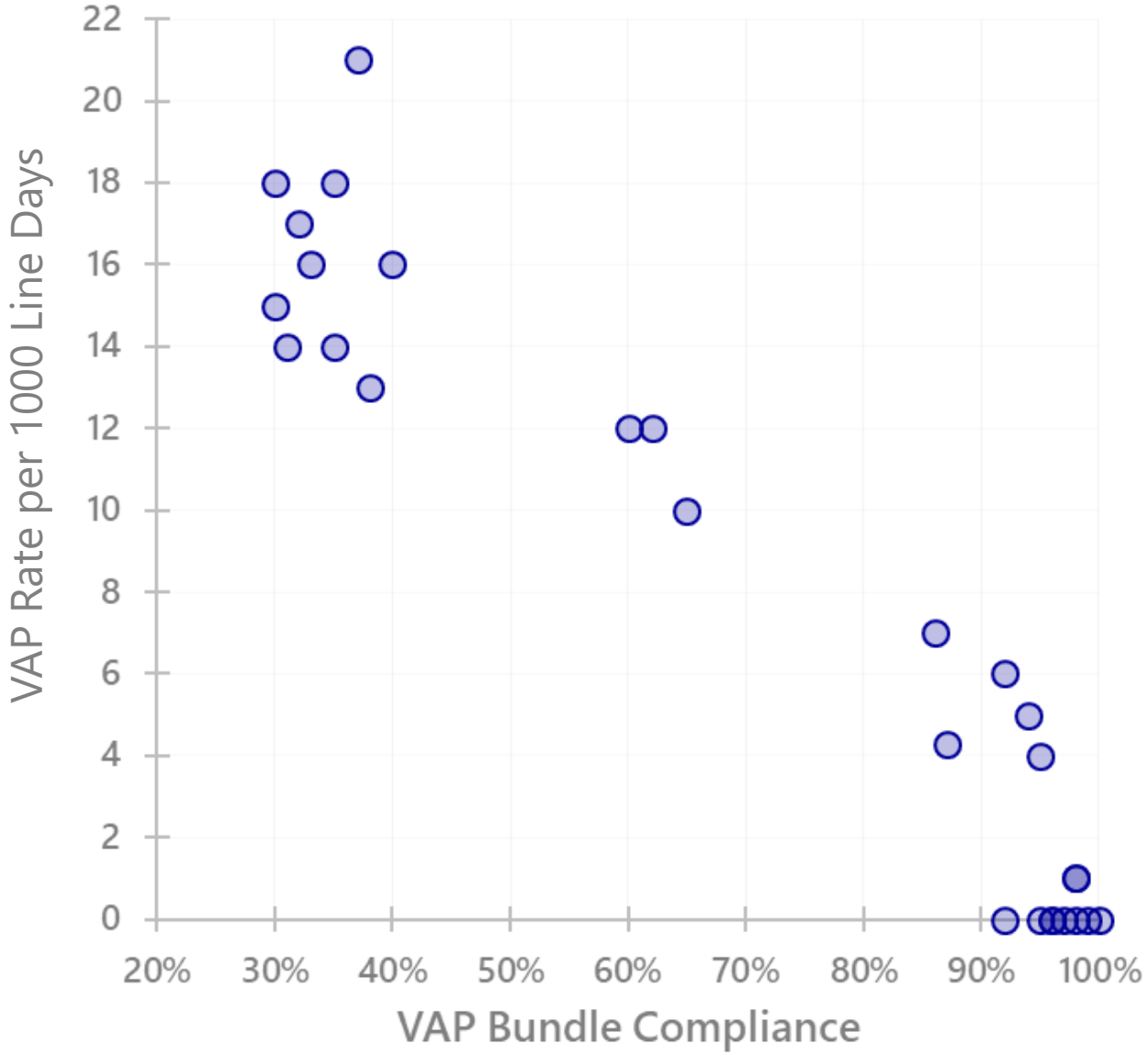
HC Data Guide, p 61-64

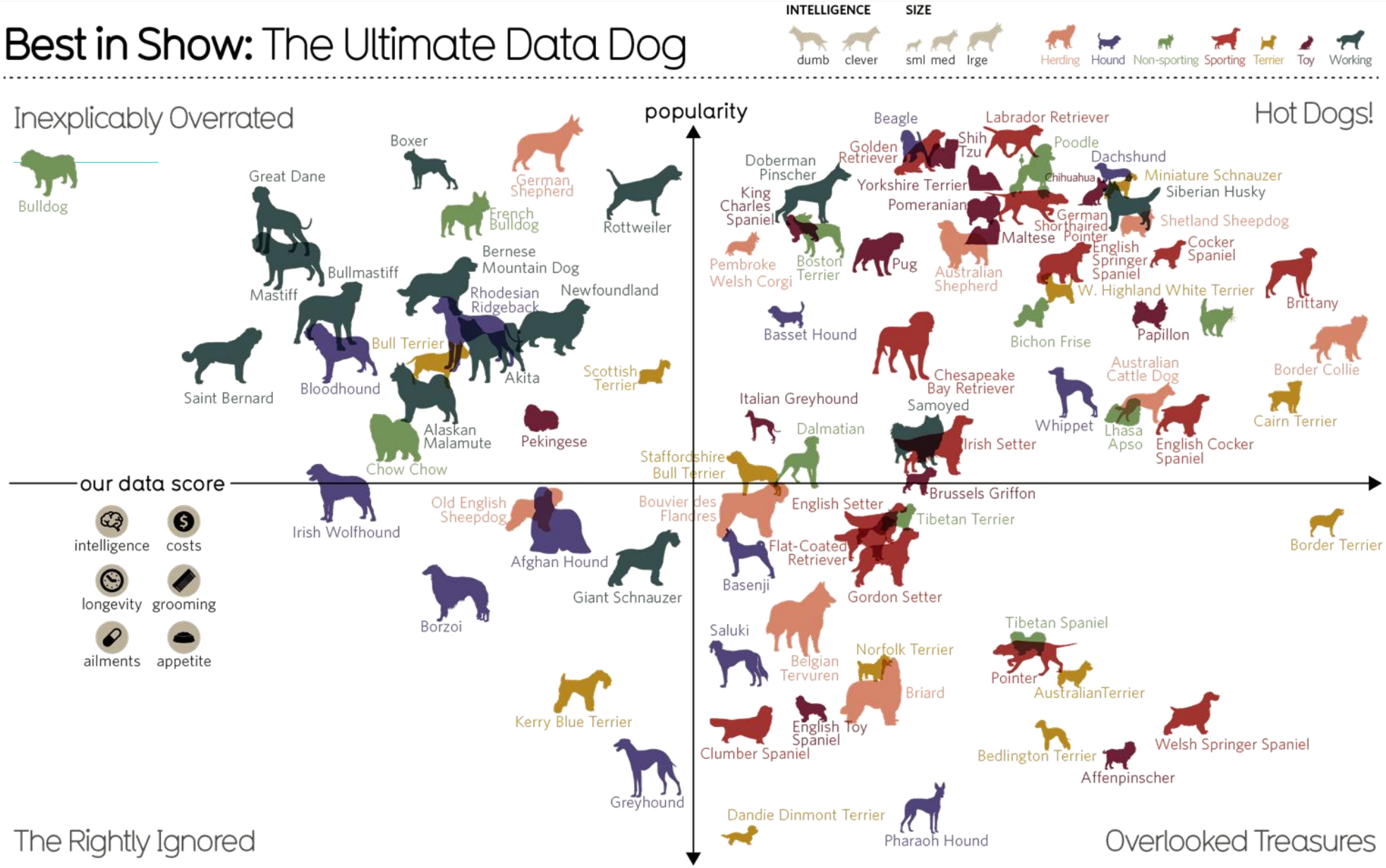
Improving scatter plots

Default Scatterplot in Excel
Room for Improvement



Care bundle introduced to reduce Ventilator Associated Pneumonia





Scatter plots are also useful to define “super categories”.

The location or quadrant of different individuals or subgroups can lead to insights.

Bubble Chart

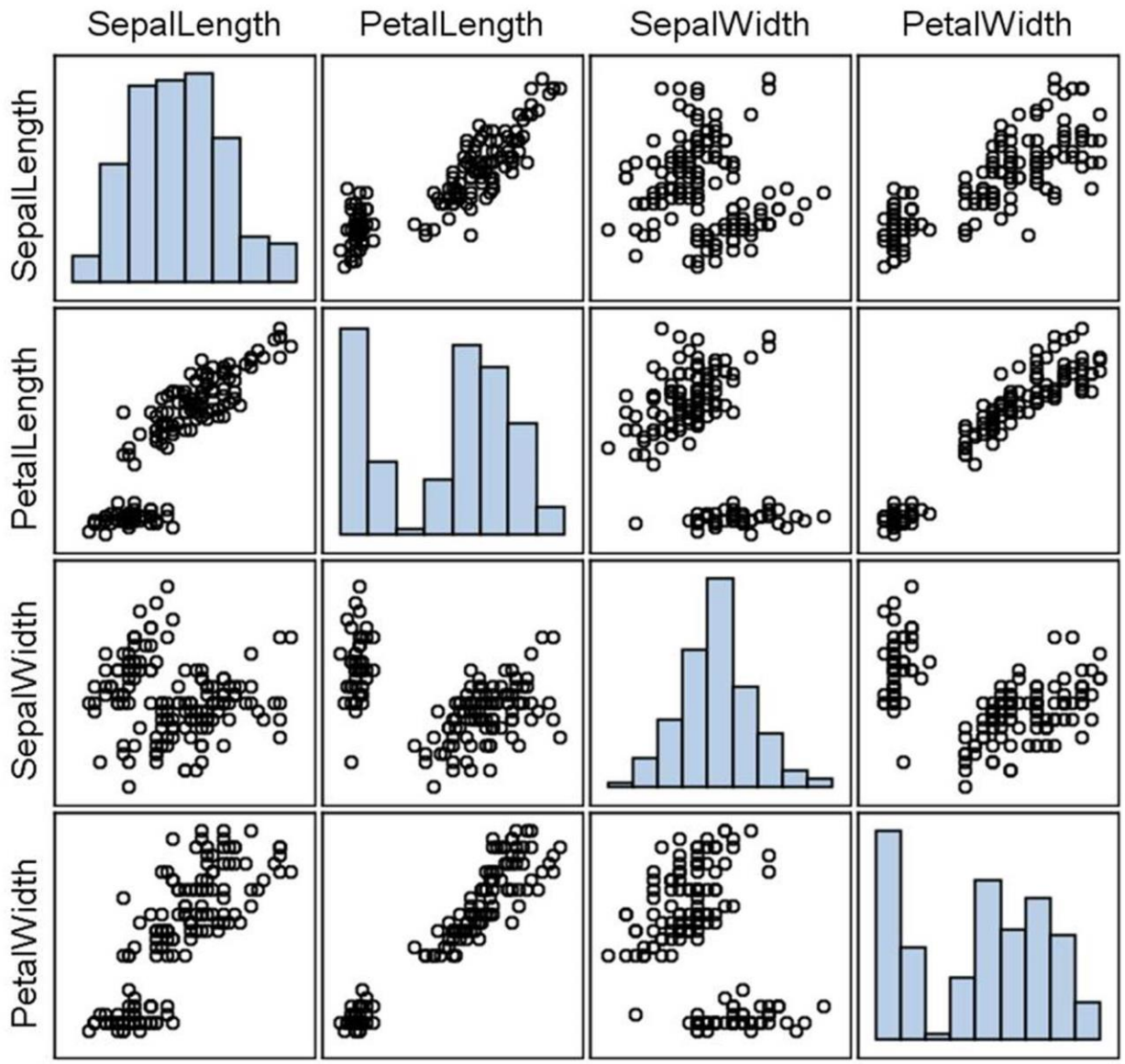
A variation of the Scatter Plot that incorporates a *third variable* represented by the size of bubble (population here).

Color can be used to encode information about an additional another variable.

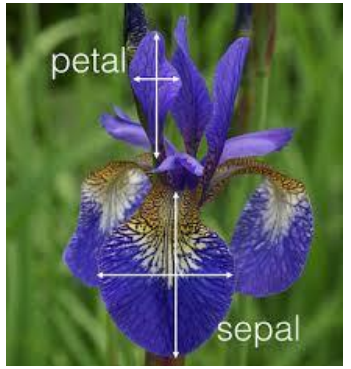
www.gapminder.org

Visualizing correlations between variables in SAS

Rick Wicklin August 26, 2011



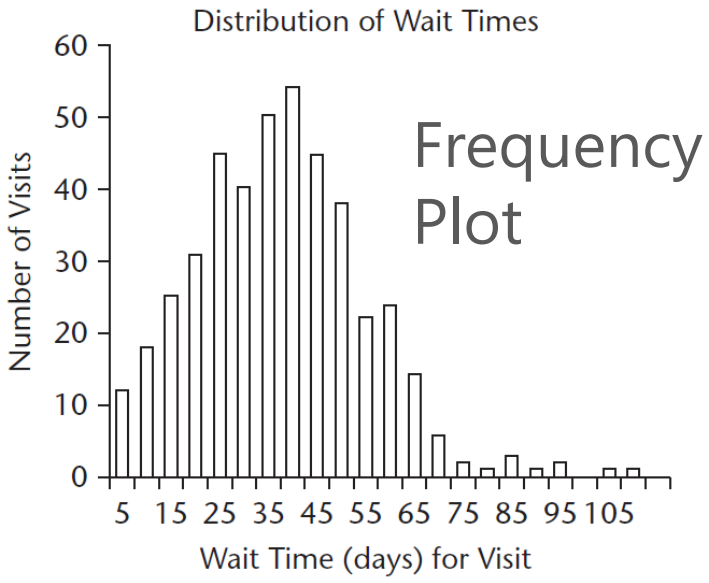
A **scatterplot matrix** – *with* ***frequency plots*** *on the diagonal* – is a good option for exploratory analysis, showing the distribution of each variable as well as potential associations between variables.

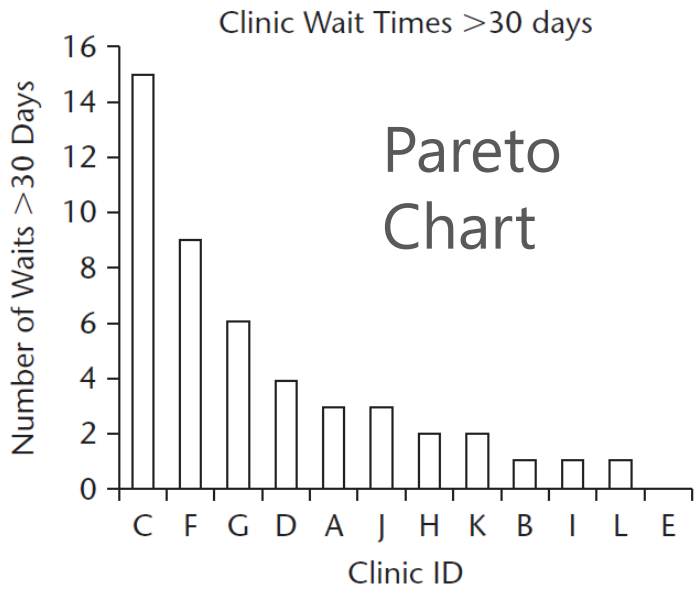


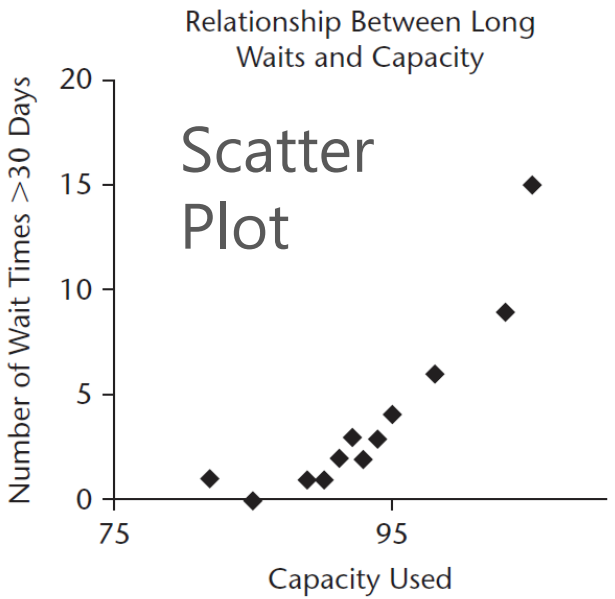
Anderson's "Iris data set" was introduced by R. A. Fisher in a 1936 paper.

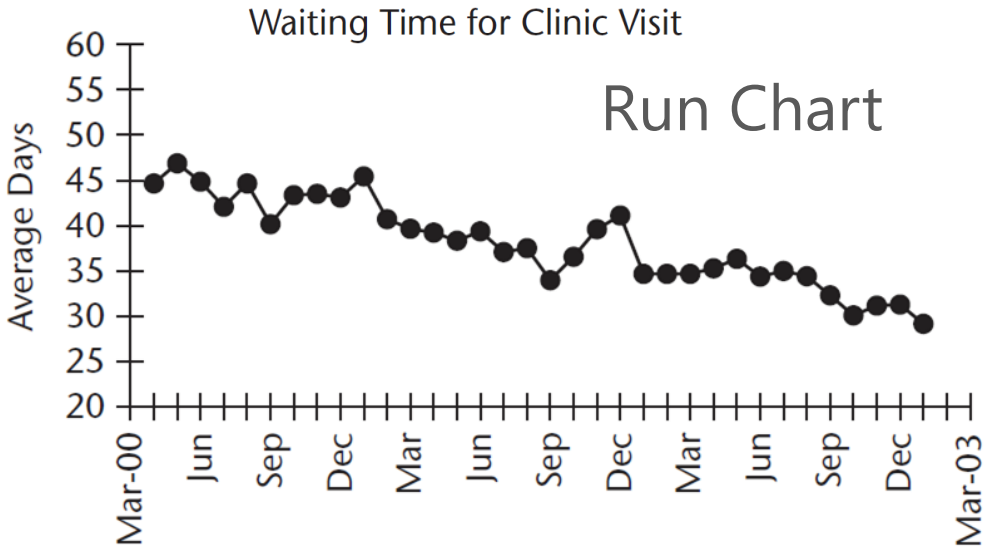
https://blogs.sas.com/content/iml/2011/08/26/visualizing-correlations-between-variables-in-sas.html

Chart Selection Exercise









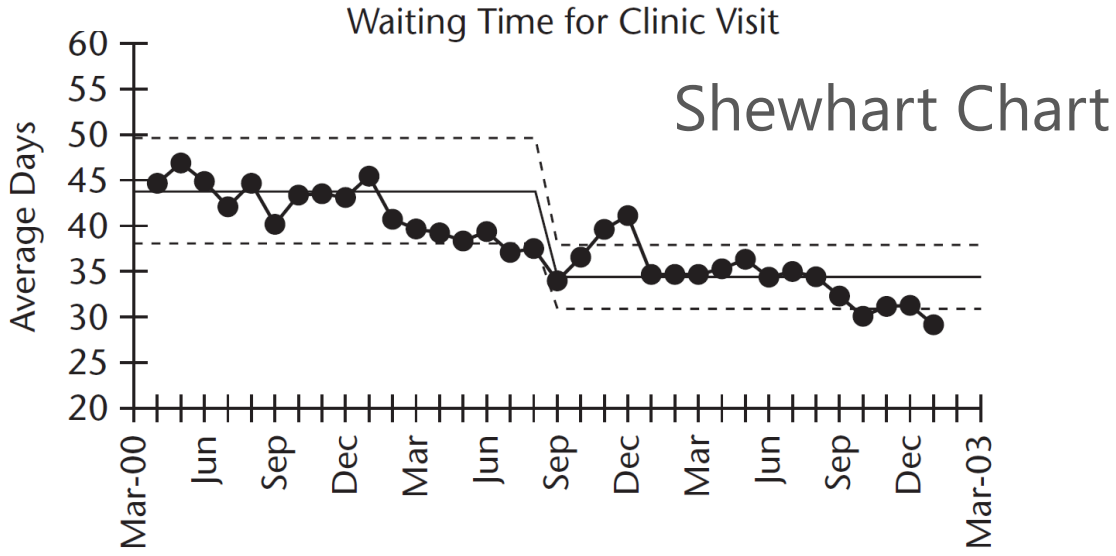
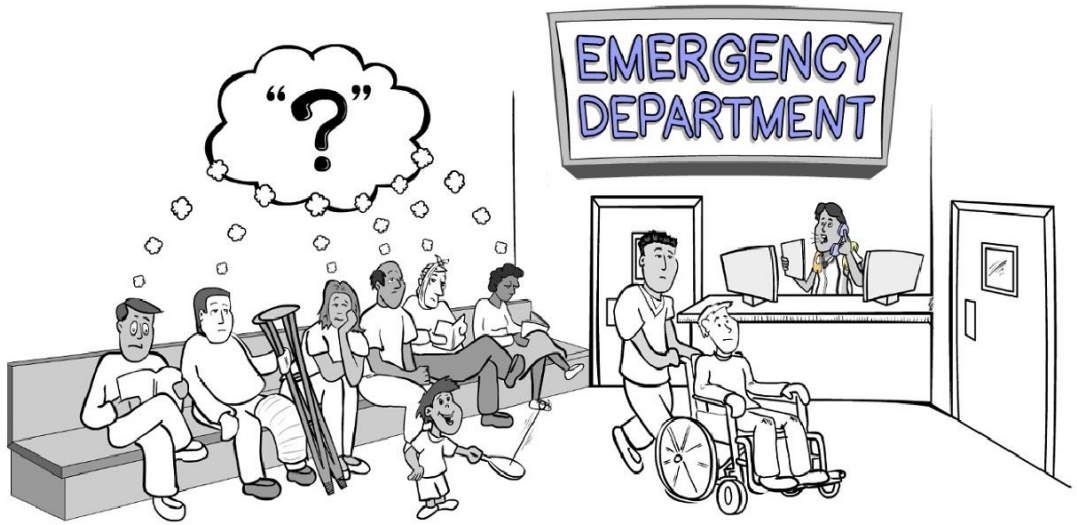


Chart Selection Exercise: Reducing Length of Stay in the ED



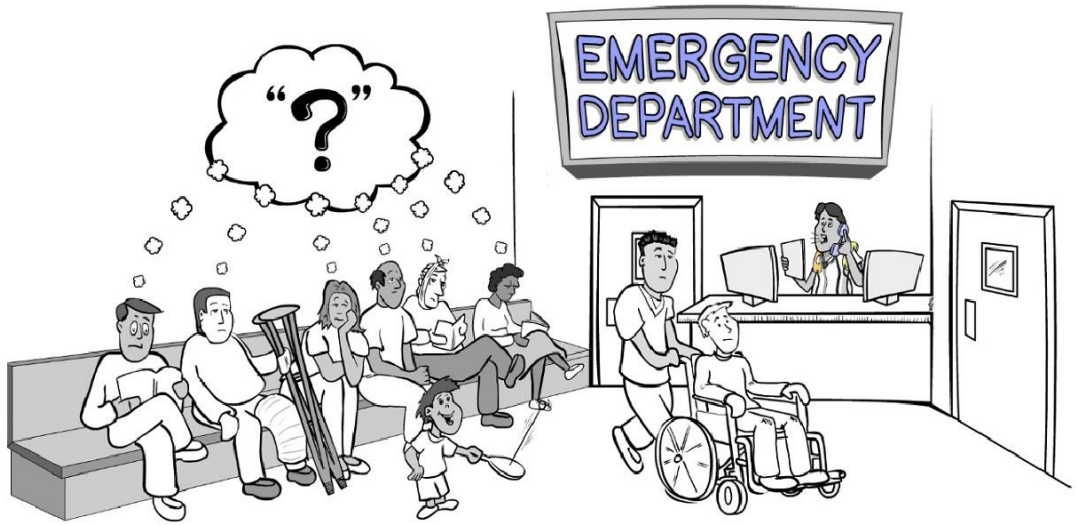
An improvement team seeks to reduce length of stay times in the Emergency Department.

They design a PDSA cycle to assess the current system of patient flow and to develop ideas for improvement. You volunteer to prepare graphical displays to help them summarize results.

What types of charts will you create?

Chart Selection Exercise: Reducing Length of Stay in the ED

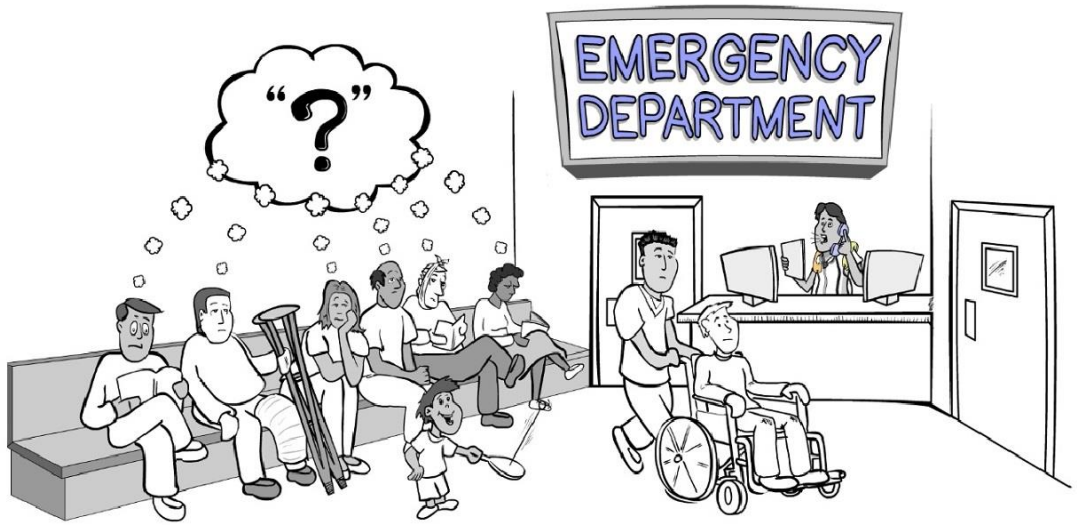
An improvement team seeks to reduce length of stay times in the Emergency Department.



For three weeks, ER staff recorded at the end of each hour:

- the number of patients arriving during the hour,
- the total time in the ED (arrival to discharge) for each patient
- the reason for delay if a patient's total time in the ED (arrival to discharge) exceeded 3 hours

Chart Selection Exercise: Reducing Length of Stay in the ED



You volunteer to help the improvement team summarize data from the first PDSA cycle.

ER staff recorded hourly data on:

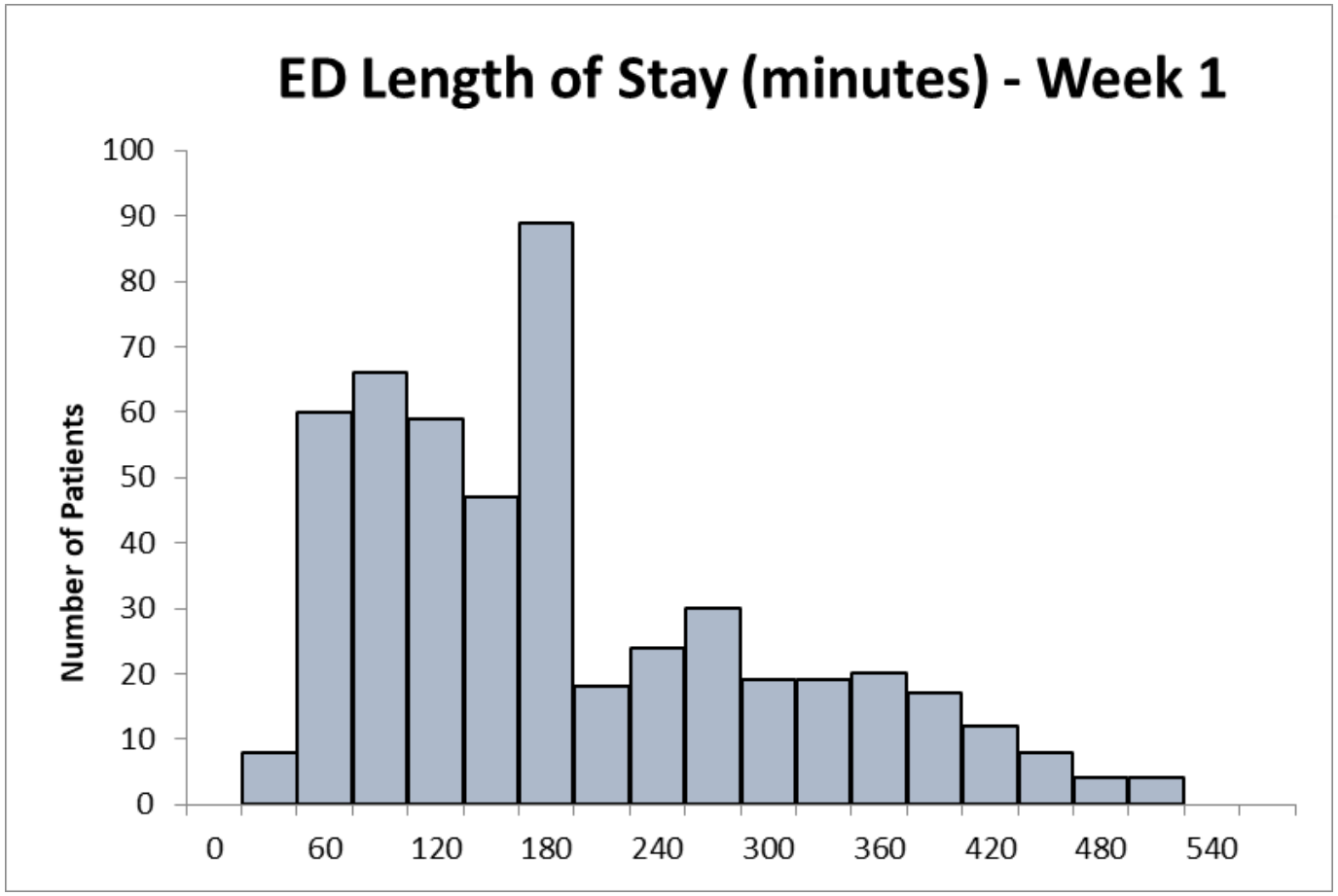
- count arriving patients during the hour,
- total time for each ED patient,
- reason for delay if total ED time >3 hours

1. **How long are patients waiting? Are there any unusual patterns resulting from the measurement process?**

Which chart or charts should we use?

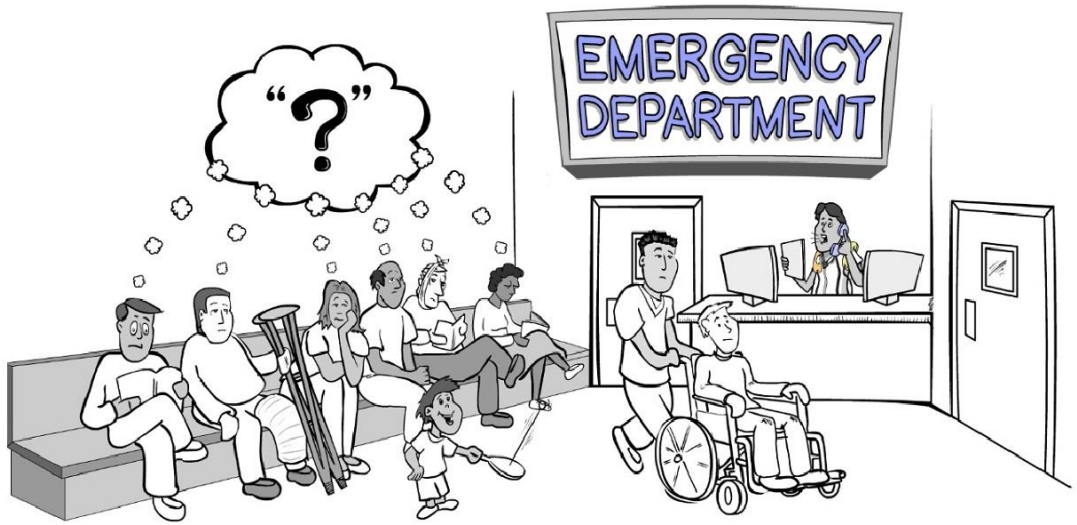
Please type your chart choice and comments into the chat window.

1. How long are patients waiting? Are there any unusual patterns resulting from the measurement process?



Use a FREQUENCY PLOT

Chart Selection Exercise: Reducing Length of Stay in the ED



You volunteer to help the improvement team summarize data from the first PDSA cycle.

ER staff recorded hourly data on:

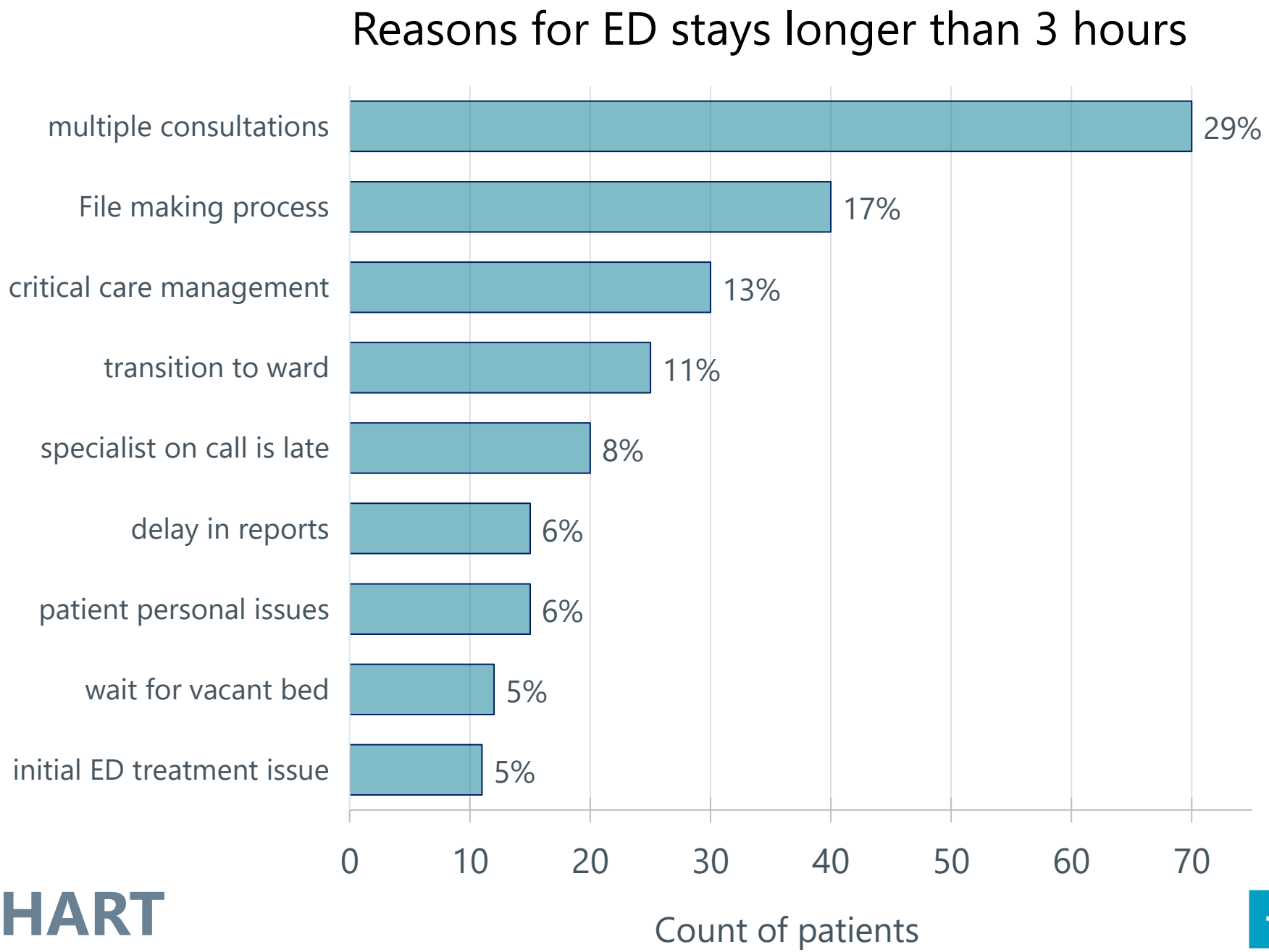
- count arriving patients during the hour,
- total time for each ED patient,
- reason for delay if total ED time >3 hours

2. What are the main reasons for delays when patients end up staying in the ED for a long time?

Which chart or charts should we use?

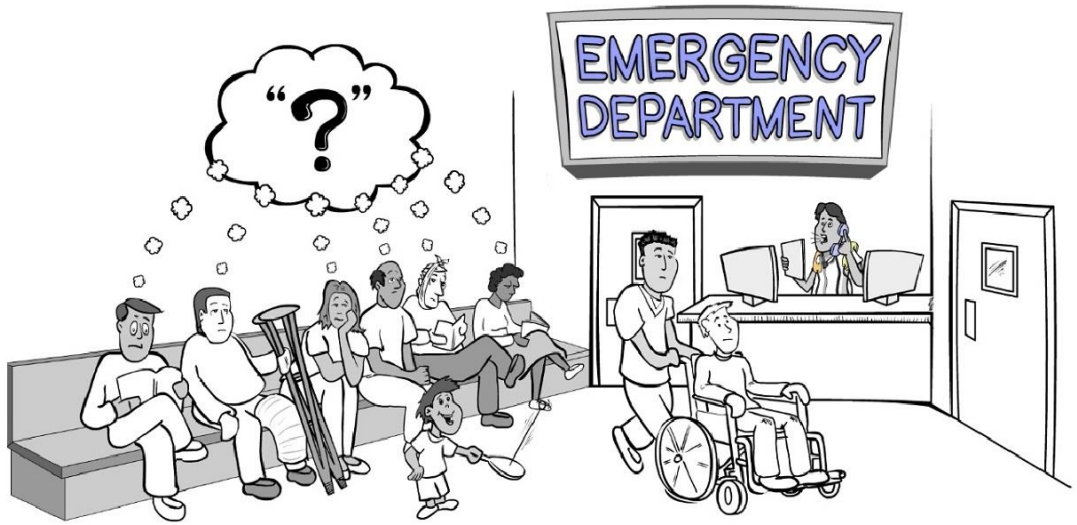
Please type your chart choice and comments into the chat window.

2. What are the main reasons for delays when patients end up staying in the ED for a long time?



Use a PARETO CHART

Chart Selection Exercise: Reducing Length of Stay in the ED



You volunteer to help the improvement team summarize data from the first PDSA cycle.

ER staff recorded hourly data on:

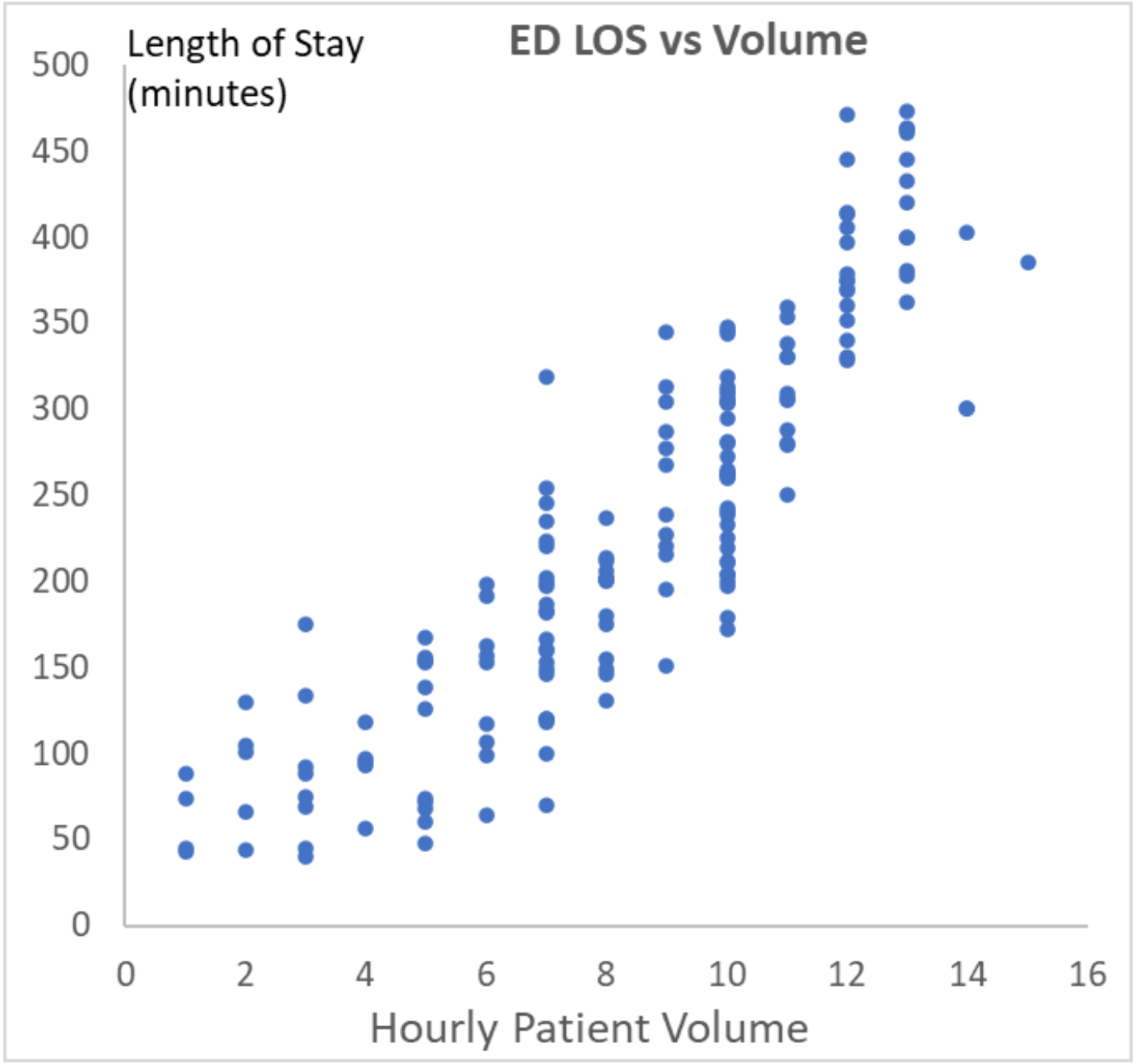
- count arriving patients during the hour,
- total time for each ED patient,
- reason for delay if total ED time >3 hours

3. How does the volume of patients in the ED affect wait times and patient flow?

Which chart or charts should we use?

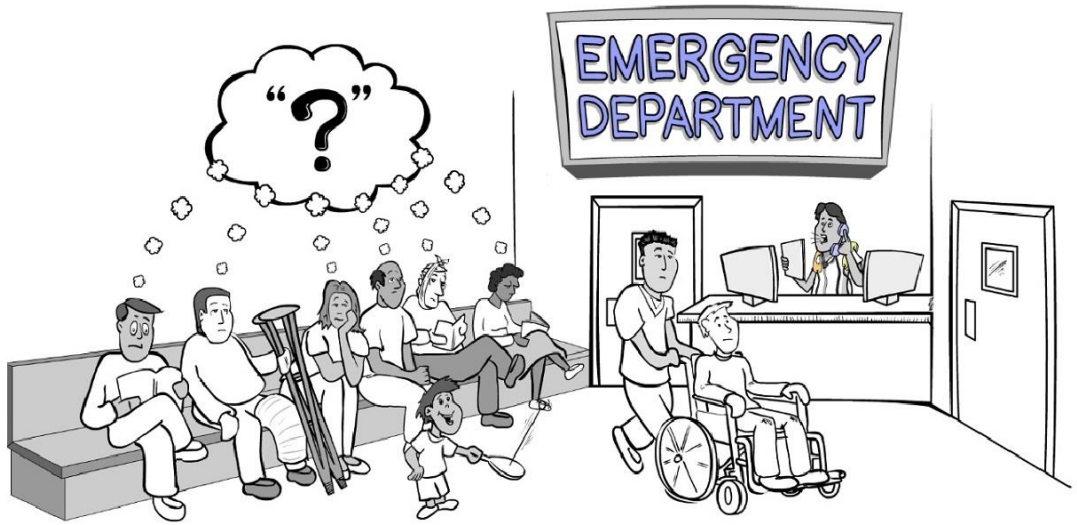
Please type your chart choice and comments into the chat window.

3. How does the volume of patients in the ED affect wait times and patient flow?



Use a SCATTER PLOT

Chart Selection Exercise: Reducing Length of Stay in the ED



You volunteer to help the improvement team summarize data from the first PDSA cycle.

ER staff recorded hourly data on:

- count arriving patients during the hour,
- total time for each ED patient,
- reason for delay if total ED time >3 hours

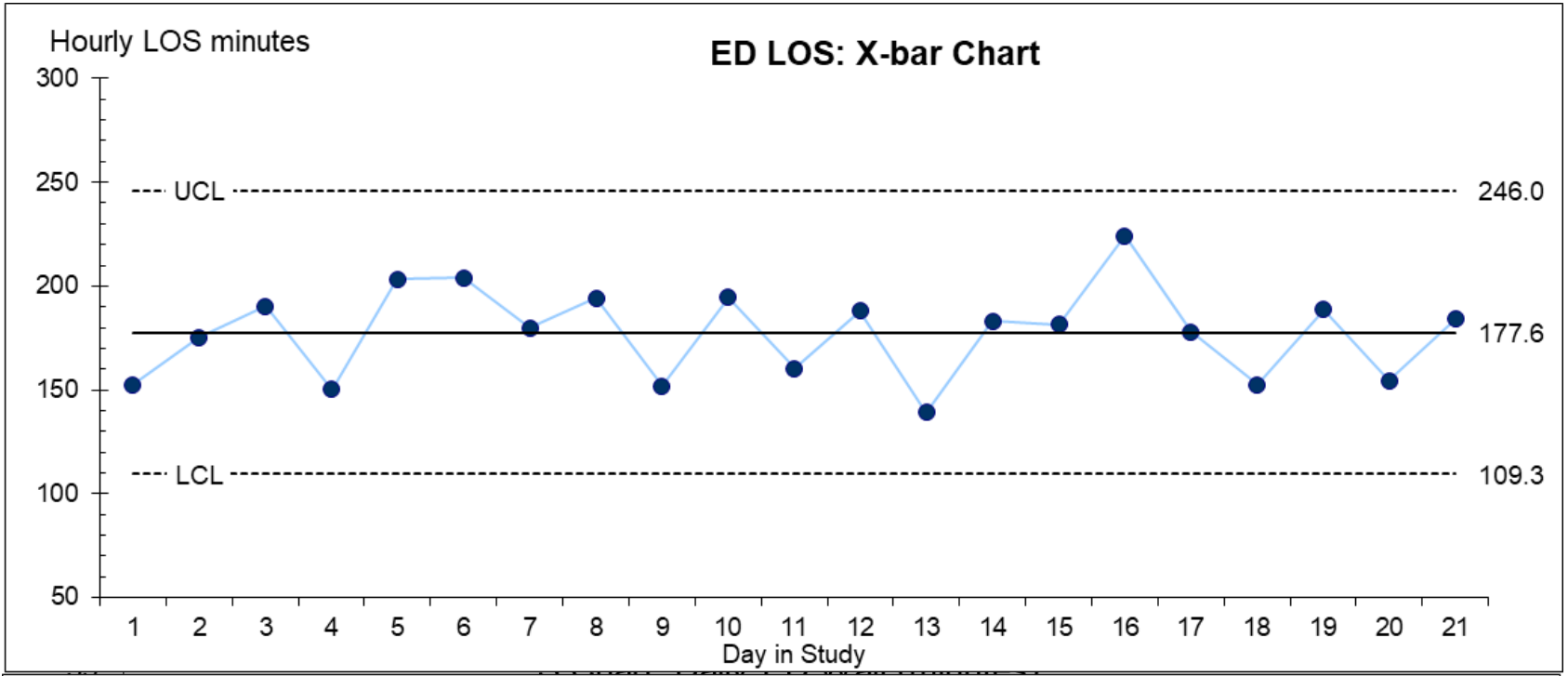
4. Do we have a stable system of patient flow in the ED?

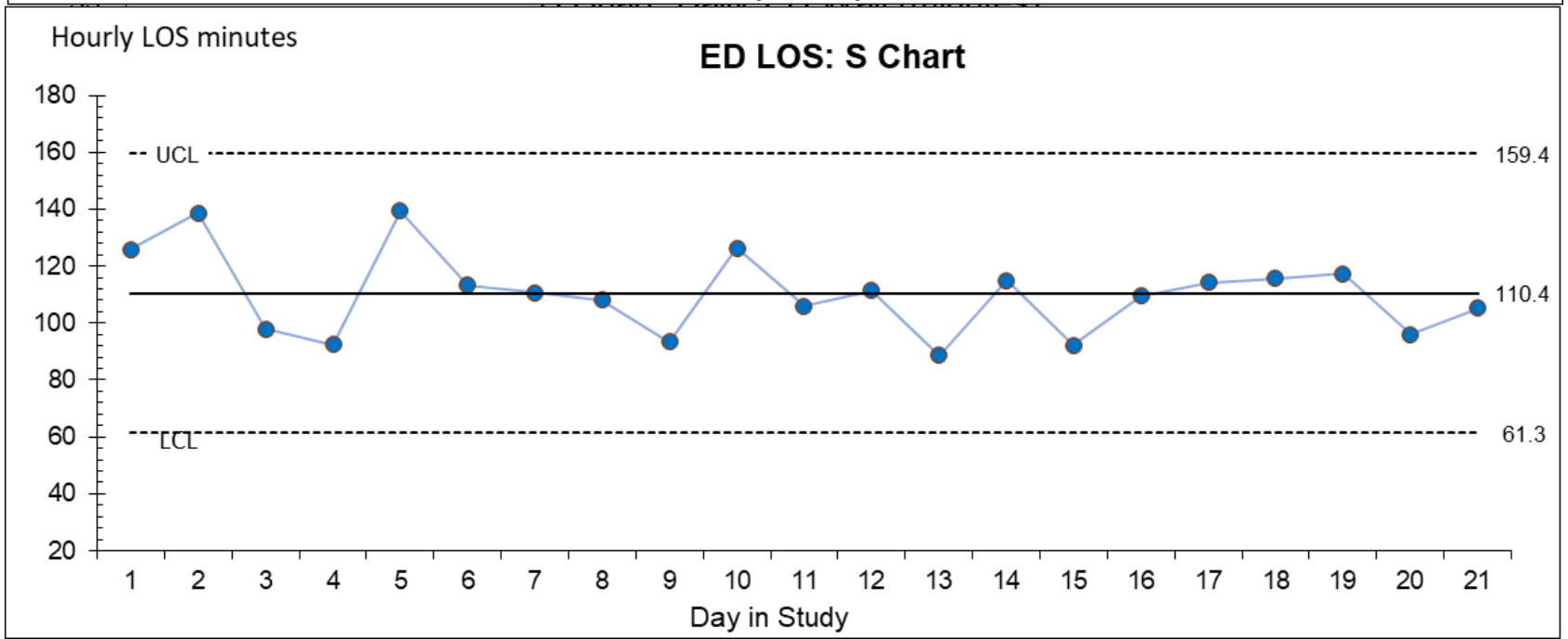
Which chart or charts should we use?

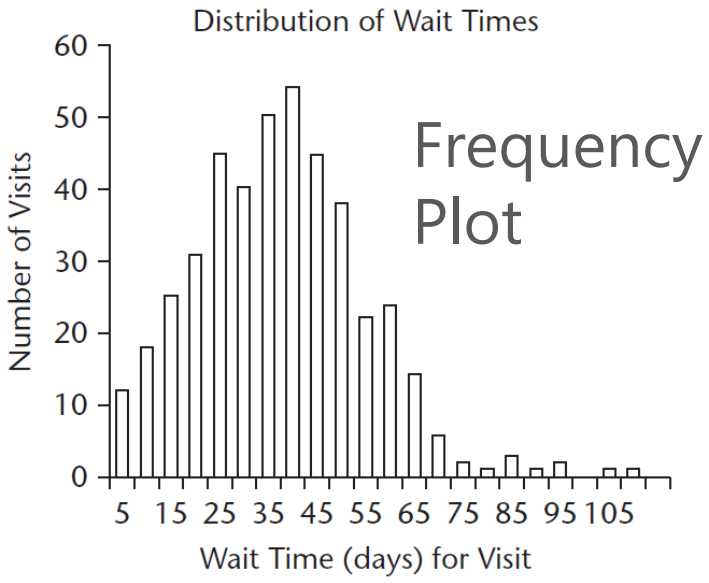
4. Do we have a stable system of patient flow in the ED?

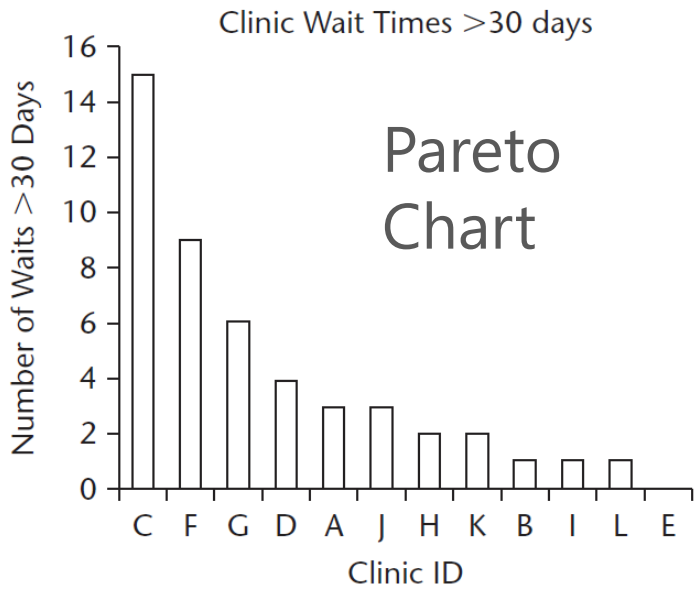
Use a *X*-Bar Chart

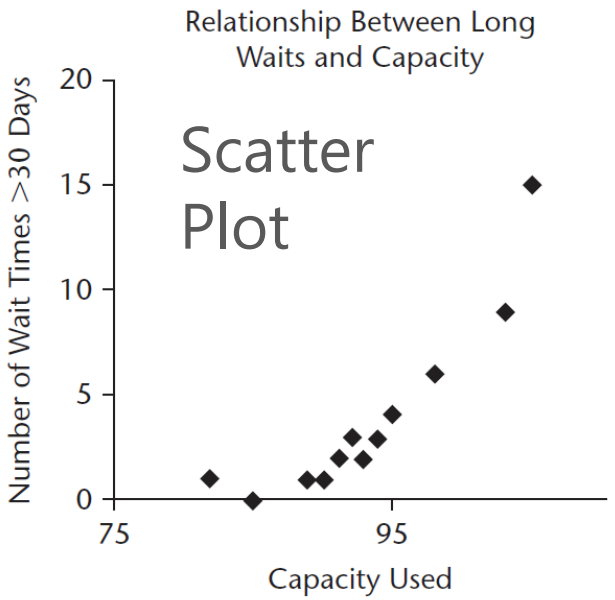
and a *S-chart*

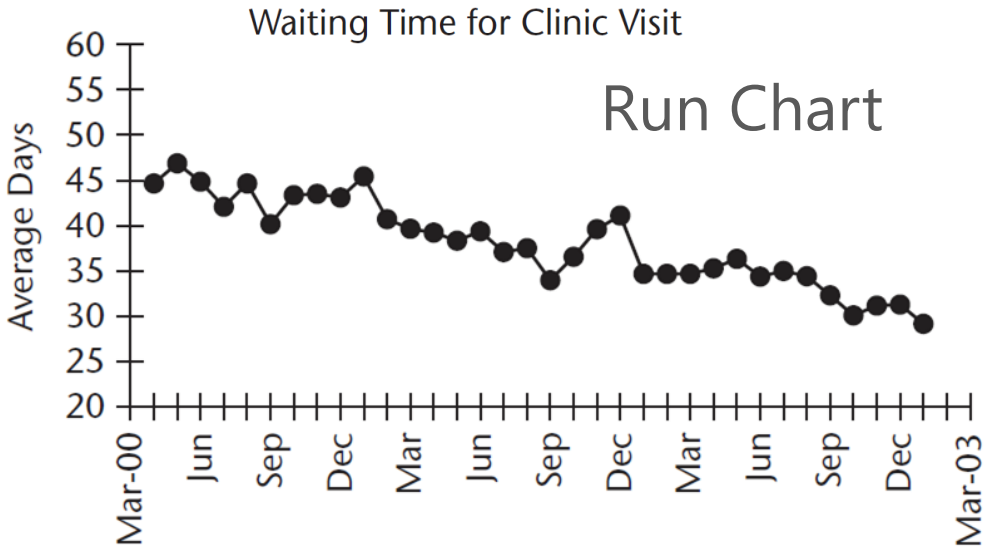


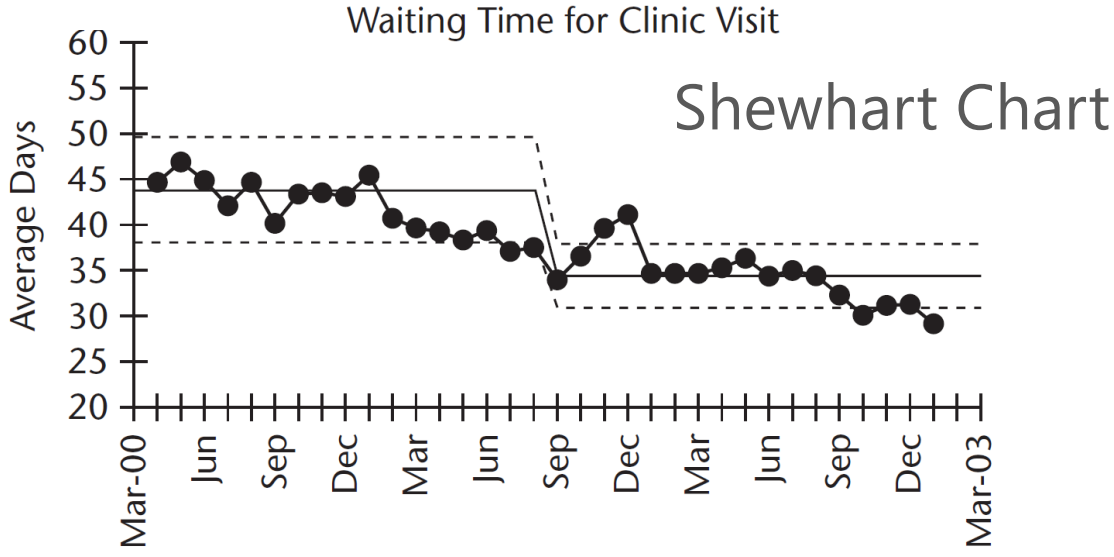




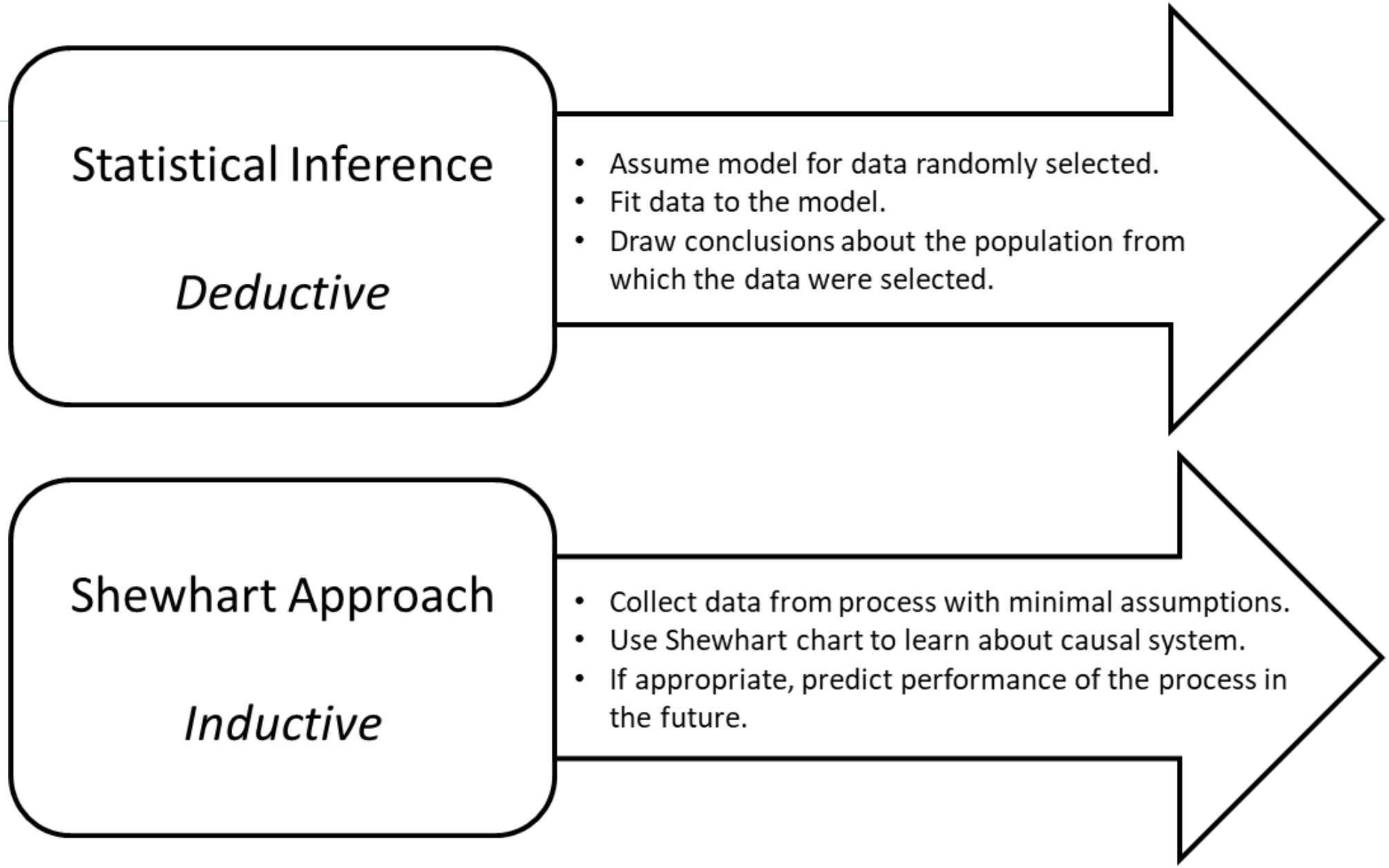




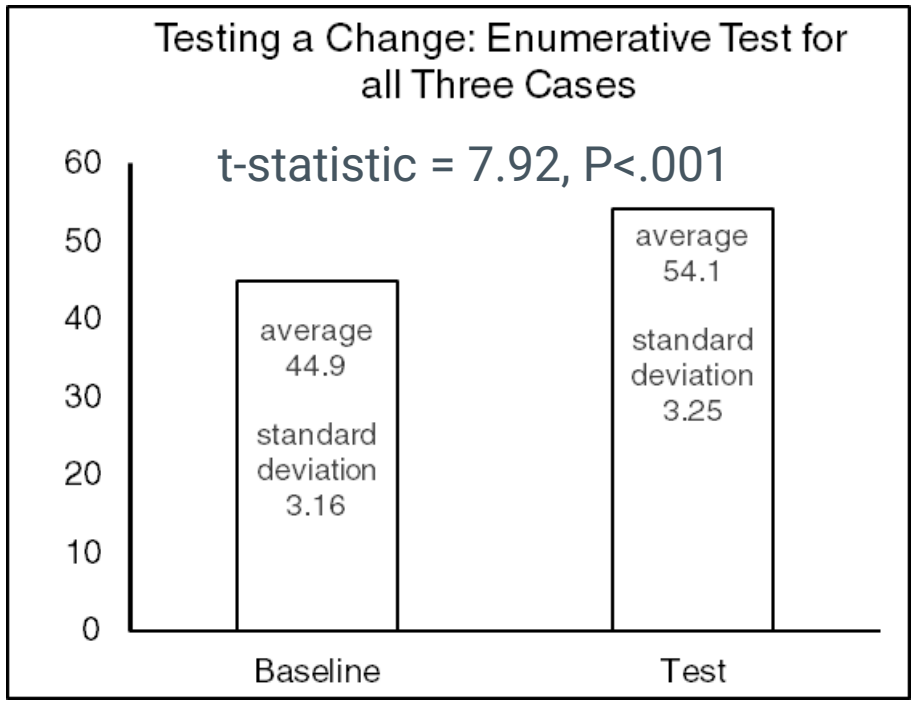


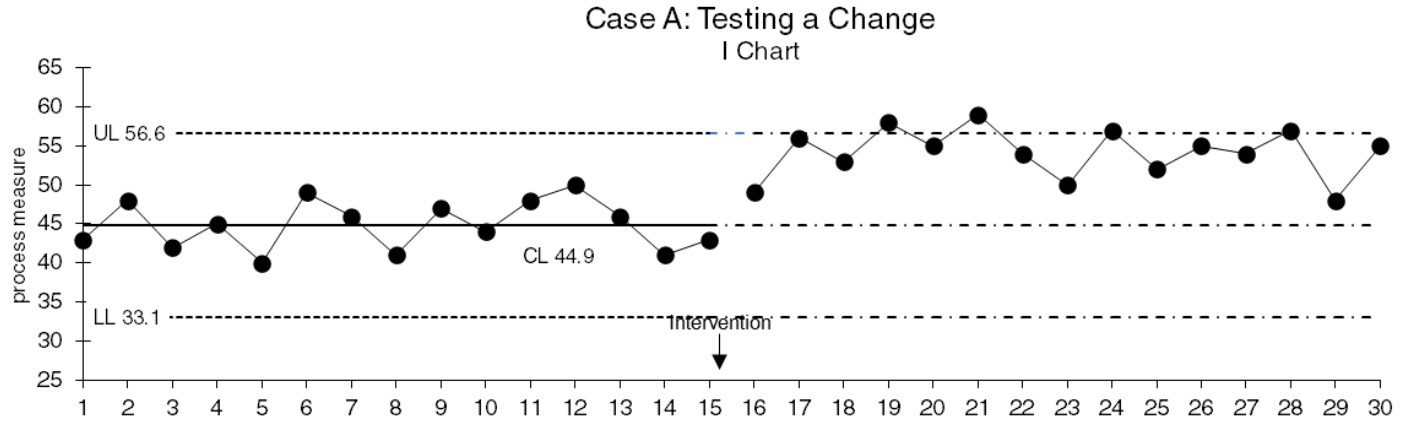


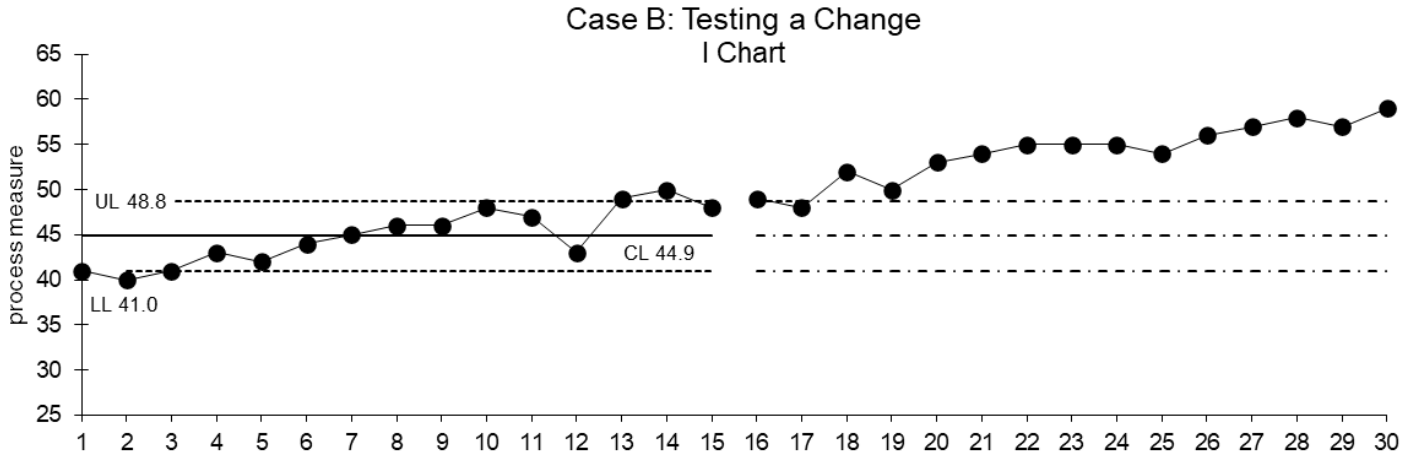
Deductive and Inductive Statistical Approaches

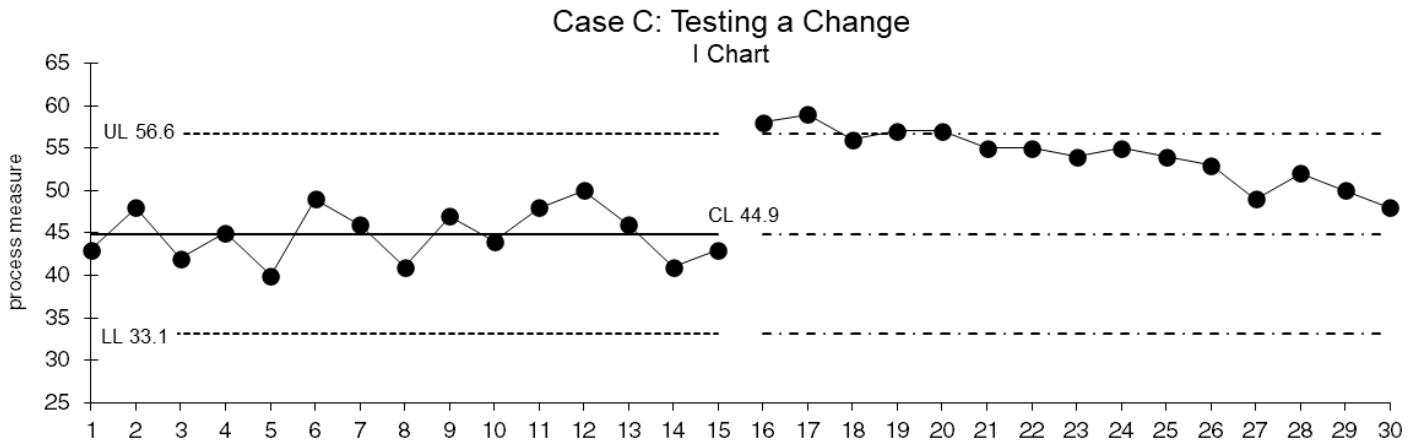


Comparison of Shewhart Chart and Statistical Inference



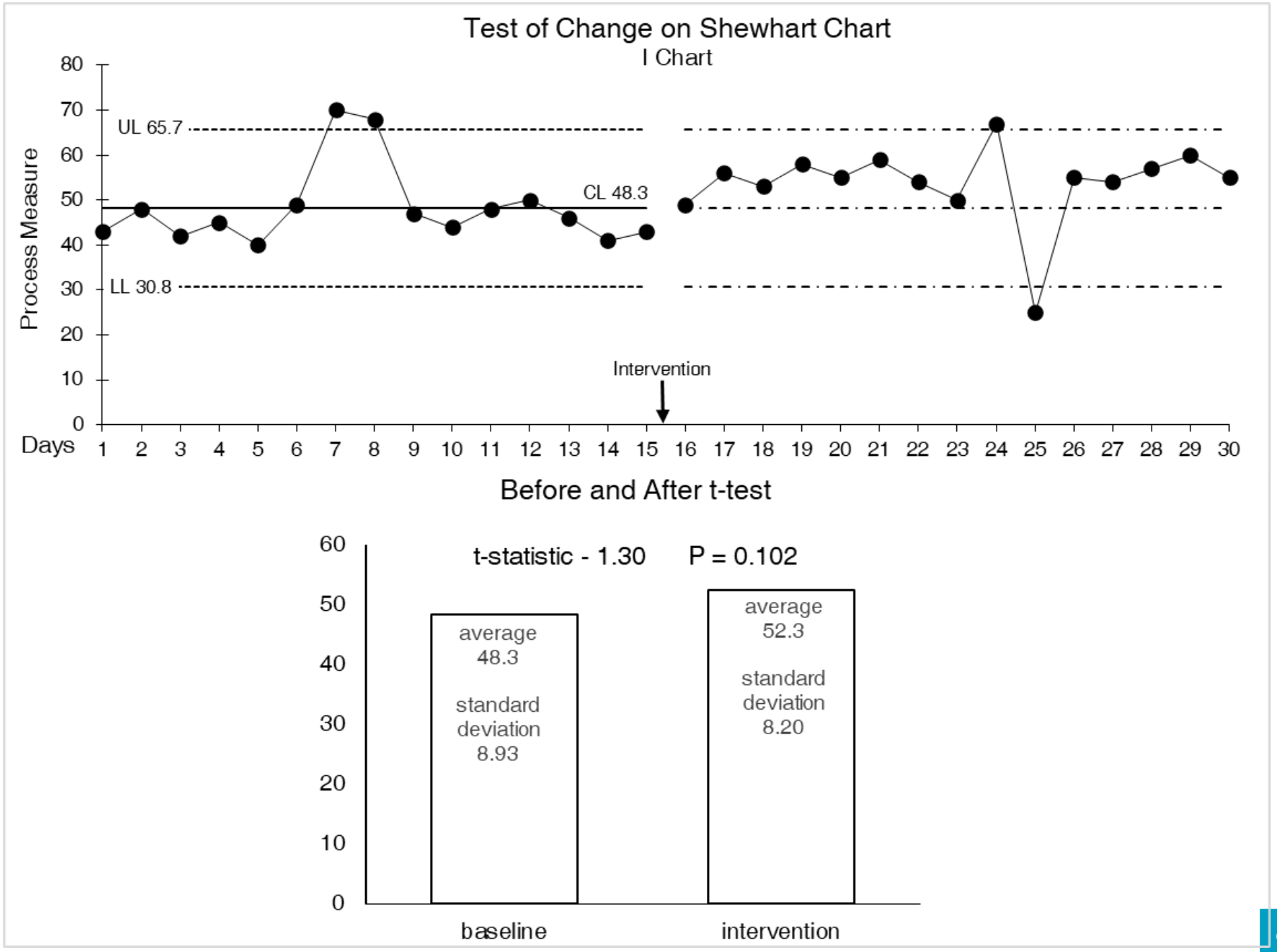






HCDG, 2nd ed, Page 294

Comparison of Shewhart Chart with Special Cause and Statistical Inference



An Opioid-free Anesthesia Protocol for Pediatric Strabismus Surgery: A Quality Improvement Project

Jennifer L. Chiem, MD; Laura D. Donohue, MD; Lynn D. Martin, MD, MBA; Daniel K. Low, BM, BS

CONCLUDING SUMMARY

Through QI methodology, leveraging PDSA cycles and SPC charts, we optimized an anesthesia protocol for strabismus surgery that eliminated the need for intraoperative opioids without increasing postoperative morphine requirements and achieved zero PONV rescue medication administration. We present our methods of using real-world data to improve our pediatric population's outcome measures and successfully established an opioid- free, nausea-free protocol for strabismus surgery not previously published.

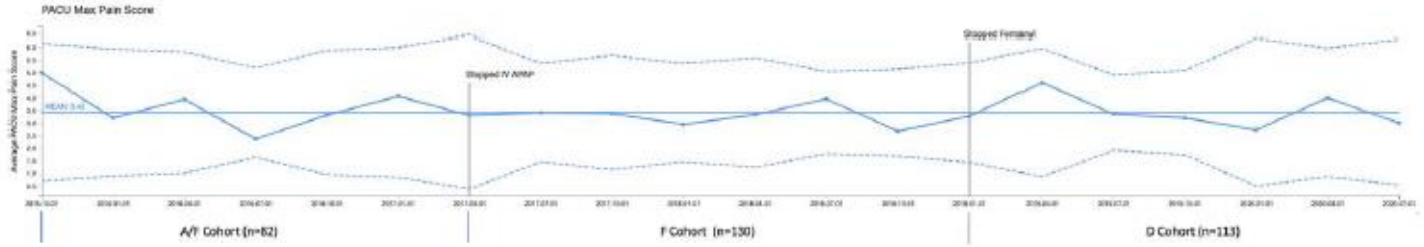


Fig. 1. Maximum PACU pain score. The dashed lines above and below the means represent the upper and lower control limits, respectively. APAP, acetaminophen; PACU, postanesthesia care unit.

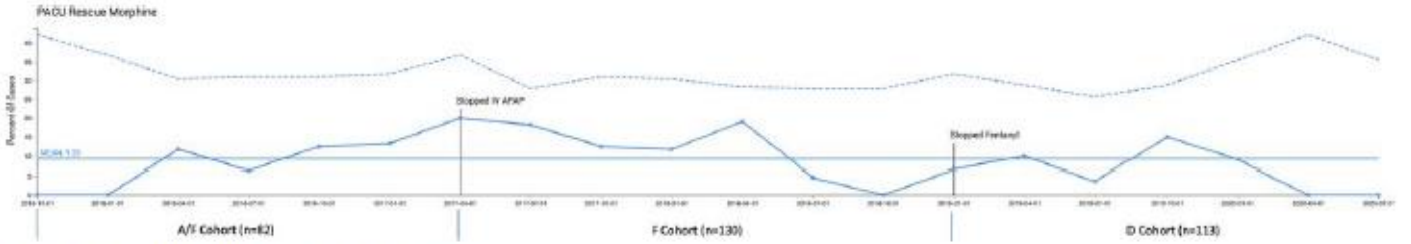


Fig. 2. Post-operative morphine rescue rate.

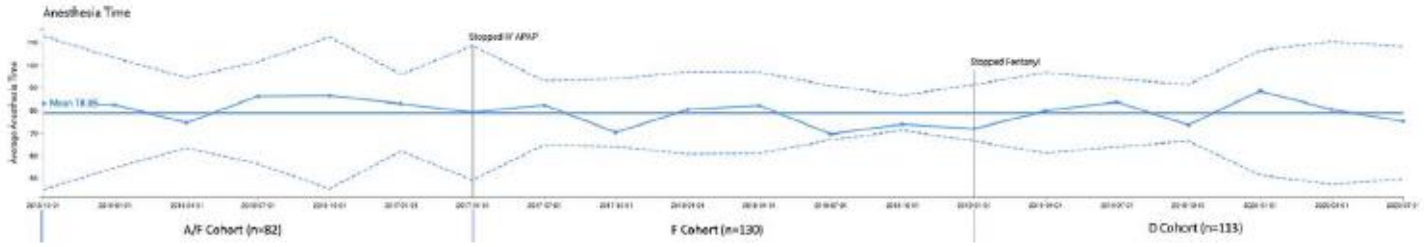


Fig. 3. Total anesthesia time.

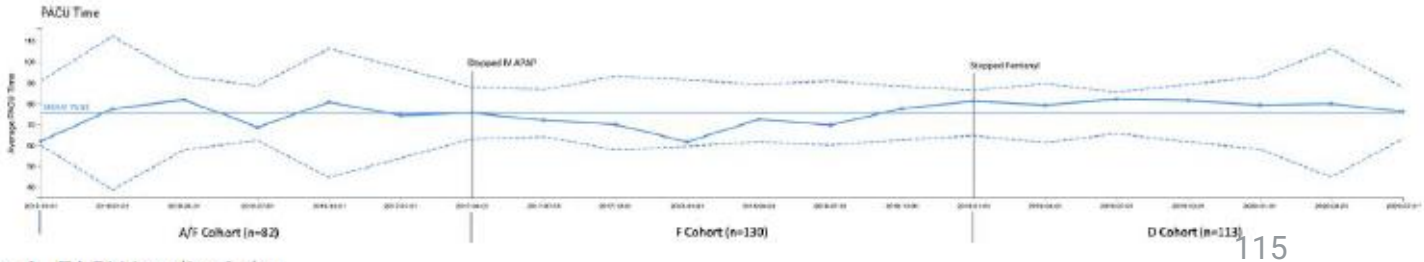


Fig. 4. PACU length of stay.

Chiem JL, Donohue LD, Martin LD, Low DK. An Opioid-free Anesthesia Protocol for Pediatric Strabismus Surgery: A Quality Improvement Project. *Pediatr Qual Saf* 2021;6:e462. August 26, 2021

Understanding variation and the “story” in the data.

Context matters…

Extermeironingrivelin.jpg (960×1280) (wikimedia.org)

Qualitative versus Quantitative Data

	QuaLitative	QuaNTitative
Data	**Non-numeric**, Things we cannot measure or count: love, gaining maturity, mutual respect; experiences, feelings, perceptions, beliefs, insight	**Numeric**: Things we can measure and count
Data provide	Description	Measurement
Learn About	Meaning, Experience, Context, Culture/Climate	Trends, Magnitude, Amount
Goal	Depth	Generalisability
	Truth? Bias? Subjectivity	

Slide adapted from Jane Taylor and Donna Luff

What you might want to learn about…

Meaning

- What the current system means from different perspectives (clinicians, patients, families, communities etc.)

Experience

- The experience of improving a system or implementing an intervention

Context

- The context in which new implementation is introduced

Culture

- The safety culture/climate of an organisation or aspects like joy in work

Slide credit: Donna Luff, IHI Scientific Symposium

Data Types and Sources

interviews,
focus groups,
autobiography,
oral history

Words

letters, feedback,
open-ended survey
questions, policies,
books

Docs

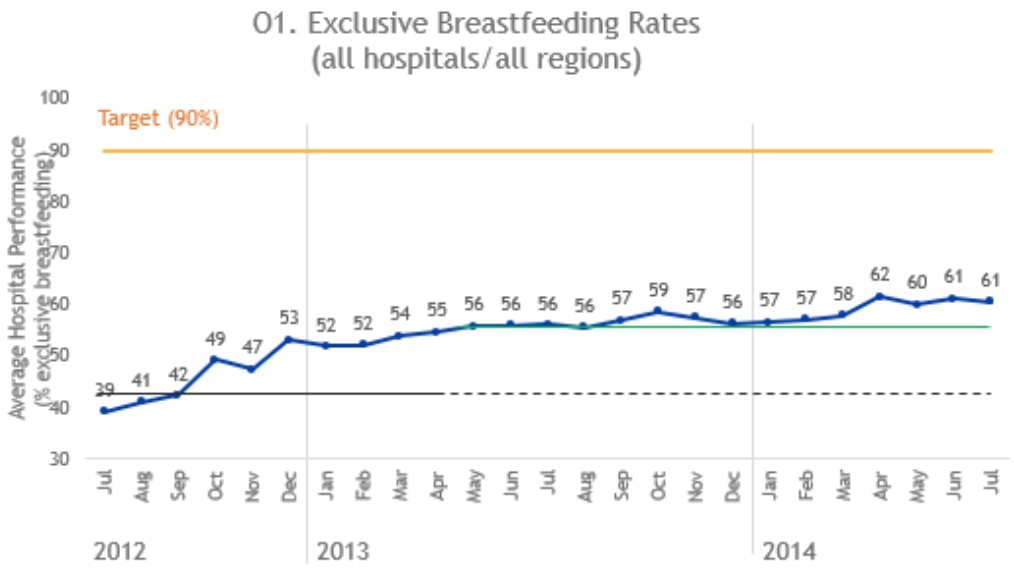
observation, video

Deeds

Cartoon from http://sheilabrobinson.com/tag/surveys/

What CAN we learn from these data?
What CAN'T we learn? Variation at the level of hospital

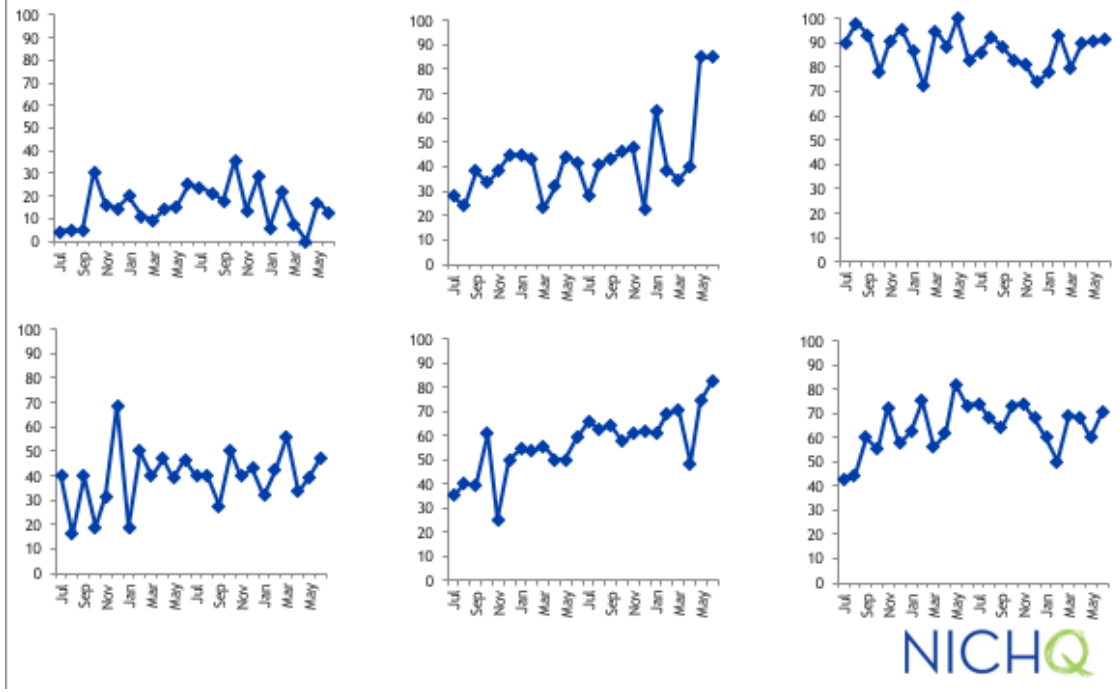
Outcome Measure:
Exclusive Breastfeeding Rates



*Self-reported data from the 89 participating hospitals

NICHQ

Exclusive Breastfeeding Rates



NICHQ

Slide Credit: McPherson (2014), IHI Scientific Symposium.

Data from Best Fed Beginnings Initiative, National Institute for Children's Health Quality

A window into the why behind variation: Voices from project participants

“Some nurses and pediatricians still want to grab the old formula bottle—too easy! Even with education [they] want to follow old paths.”

“Gaining buy-in from the physicians has been difficult at best.”

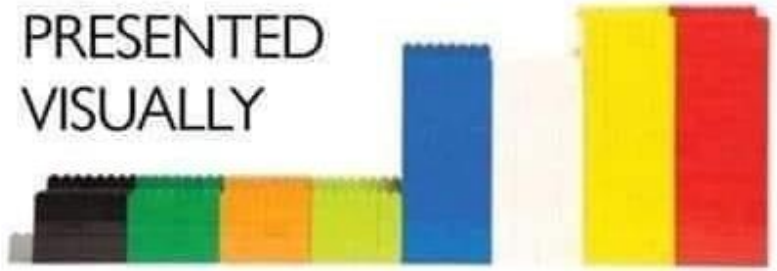
“Numerous staffing and administrative changes in that unit have made implementation of standard teaching [on breastfeeding] an ongoing challenge.”

DATA

SORTED

ARRANGED

PRESENTED
VISUALLY



EXPLAINED
WITH A STORY

"Statistics are human beings with the tears wiped off."

Paul Brodeur, quoted in Mukherjee's Emperor of all Maladies: A Biography of Cancer