

Student-t test assumes 2 groups with same variance. Does this m

Difference between this and analysis of means.

Analysis of means:

<https://programs.theanalysisfactor.com/statistically-speaking/trainings/analysis-of-means/>

Quality Control examples. Going to point out contra indications which nobody covers. When you shouldn't use it.

Example: Monsoon distribution. Each region is a group.

Example: referral patterns for physicians. Each physicians will have different referrals.

Example: Analysis of Means(ANOM) as a tool for comparison of Sample Treatment methods.

When you have different groups the first thing people think of is ANOVA or analysis of variance.

- 1) ANOVA vs ANOM. When to use ANOVA vs ANOM.
- 2) Control charts. There is a similarity between control charts and analysis of means. How to recognize when you should use a control chart vs. using an ANOM.

ANOVA: Illustrating ANOVA with strength study.

Stat's Amore Training Video: Analysis of Means

Please allow some time for video to appear below

Strength study, descriptive statistics

Material	N	Mean	StDev
A	6	37.73	3.36
B	6	31.57	5.50
C	6	35.98	3.73
D	6	41.07	2.64

Figure 5. Means and standard deviations from strength study

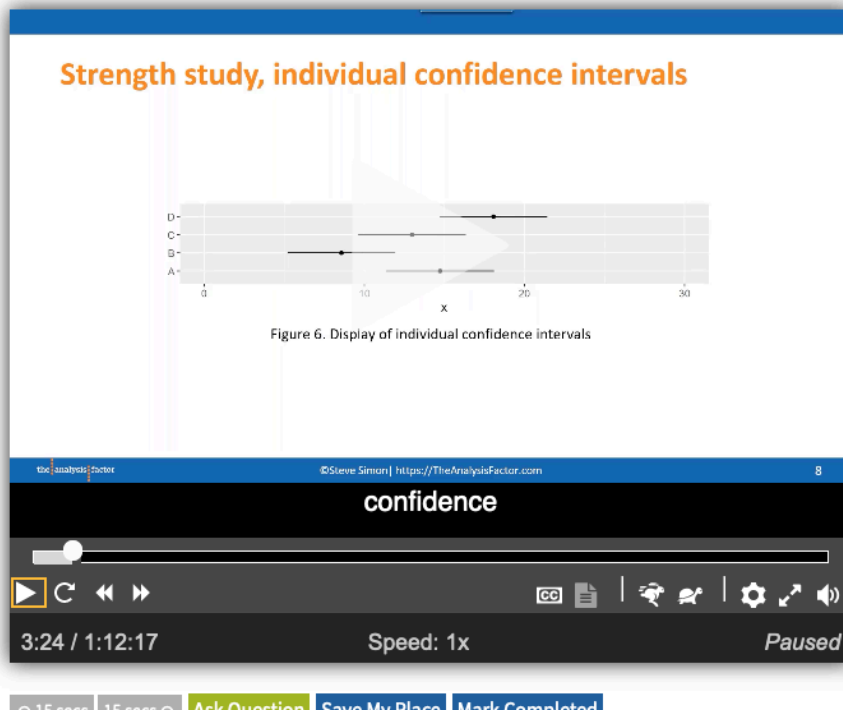
what you can see is that b is the

4 groups with means and std deviation. Comparing the material strength of the 4 groups. B is the weakest and D is the strongest.

He drew some confidence intervals

Stat's Amore Training Video: Analysis of Means

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If 2 intervals touch then one mean is not statistically significant from the other mean. This rule is wrong.

If the mean of one lies in the CI of another then it isn't statistically significant different. This rule doesn't work

Are A and B statistically significant different or same? Have to adjust we aren't looking at just A and B but all possible pairwise comparison in ANOVA framework.

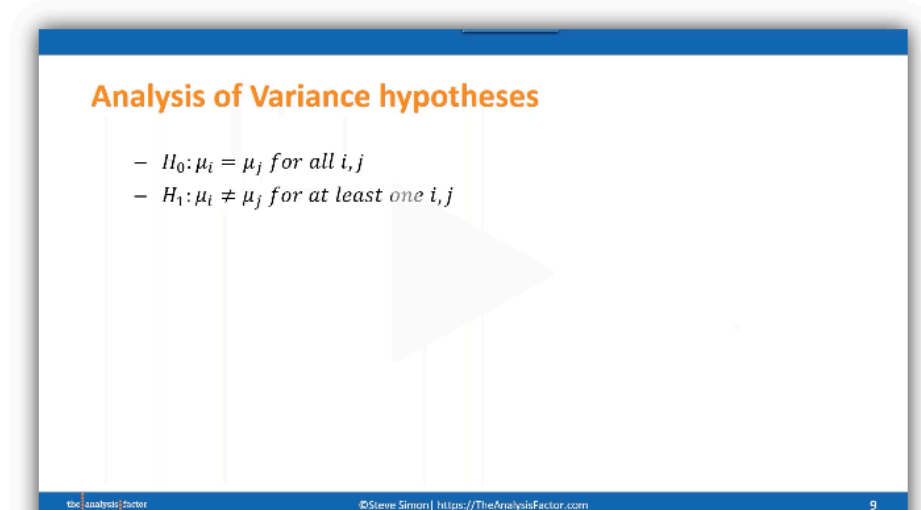
SO individual CI won't work for which material is strongest and which one is weakest.

B and D do not overlap. There is a difference but this difference may not be there after adjusting for multiple comparisons.

ANOVA hypothesis testing.

Stat's Amore Training Video: Analysis of Means

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Null hypothesis means are equal for all groups.

AH: at least 1 mean not equal.

SO you have to compare all the pairings. From the example above

AB

AC

AC

AD

BC

BD

To see if the null hypothesis is accepted or rejected.

Cant do multiple tests and take smallest pvalue. Have to make an adjustment for running multiple tests.

Verify video 8.27 this is bonferroni correction.

Strength study, ANOVA table

Method

Null hypothesis All means are equal
Alternative hypothesis At least one mean is different
Significance level $\alpha = 0.05$

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Material	4	A, B, C, D

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Material	3	281.7	93.90	6.02	0.004
Error	20	312.1	15.60		
Total	23	593.8			

Figure 7. ANOVA table

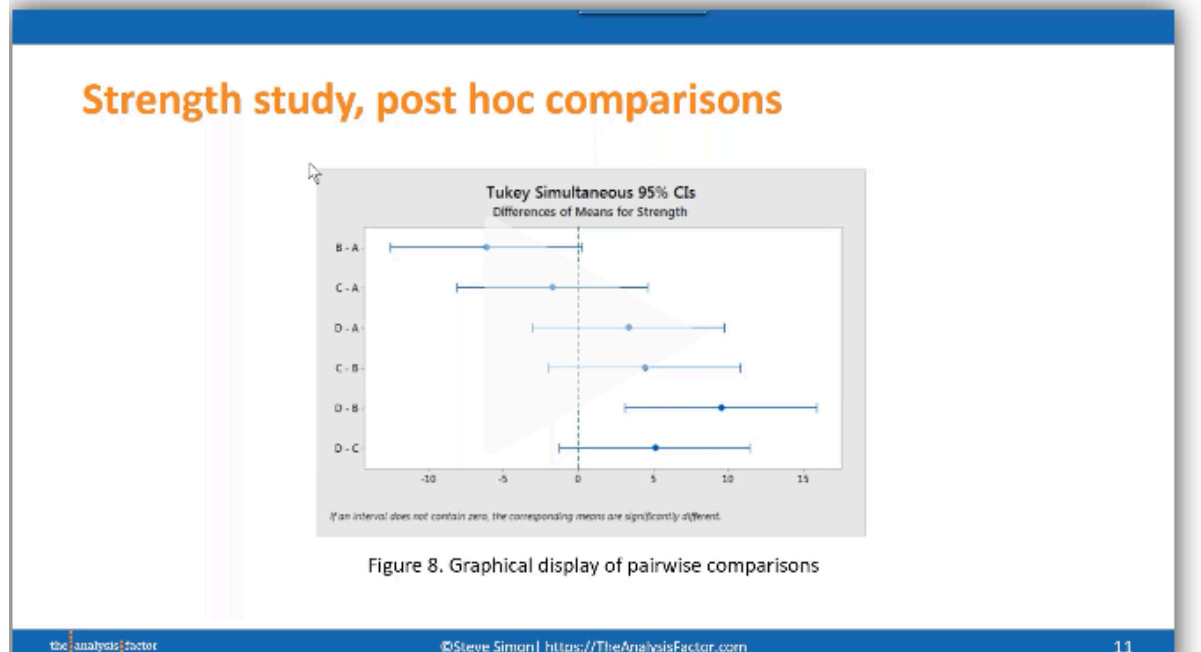
0.004 that P value is small which means

The p-value is small so there is a statistically significant difference amongst at least 1 pair of means.

What does the F-Value mean?
DF, Adj RR.

Tukey pairwise comparison of means.

Please allow some time for video to appear below



A CI which includes 0 means there is no difference. CI includes 0: B/A, C/A, D/A, C/B, D/C,

What is null hypo? ALL MEANS same, D is different than B.
D/B is positive so the D is stronger than B.

ANOVA gets worse when there are more categories.
Need more depth on this. What happens with more categories?

Control Charts:

Illustrating control charts with piston ring measurements



Figure 9. Image of piston, cylinder, and piston rings for an automobile engine

Manufacturing piston rings.

There first and last 6 days of manufacturing piston rings. Can see the mean diameter increasing at 37, the second digit is no longer 0.

Piston ring, descriptive statistics (1/2)

	Mean_diameter	Stdev_diameter
1	74.010	0.015
2	74.001	0.008
3	74.008	0.015
4	74.003	0.009
5	74.003	0.012
6	73.996	0.009

Piston ring, descriptive statistics (2/2)

	Mean_diameter	Stdev_diameter
35	74.013	0.012
36	74.004	0.013
37	74.017	0.007
38	74.020	0.011
39	74.023	0.009
40	74.013	0.012

When did the diameters start getting big and how do you know?
Plot mean diameter in time sequence

Please allow some time for video to appear below

Control chart rules (1/2)

- Plot the data in time sequence
- Add control limits at 3 SIGMA
- Out of control if:
 - One point outside of 3 SIGMA limits
 - Two out of three points outside of 2 SIGMA limits
 - Four out of five points outside of 1 SIGMA limits
 - Eight points on same side of center line

Sigma is not same as std. deviation. Sigma is measure of short term variation.

3 sigma is a measure of short term variation. Any value out of 3 sigma a process is considered out of control.

Add other measures besides 3 sigma. If you wait to observe 3 sigma it may be too late.

Last point 8 points on same side of center line. Means you drifted vs 8 points randomly up and down on different sides of center line.

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Control chart rules (2/2)

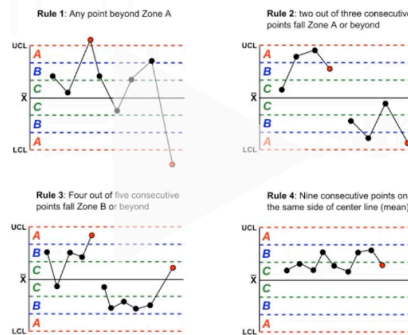
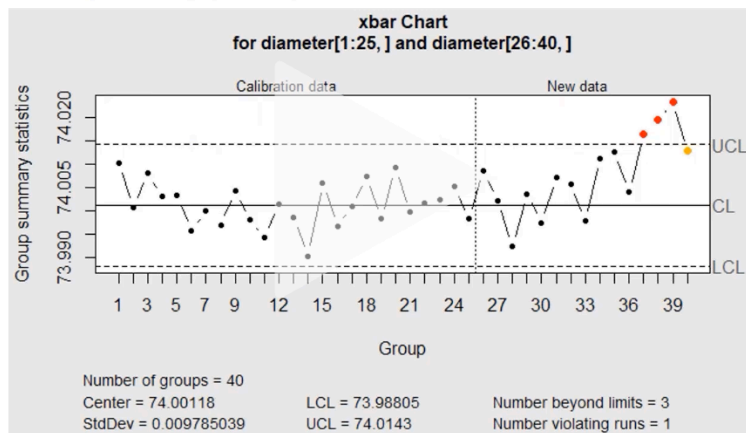


Figure 10. Illustration of control chart rules

Piston ring, control chart



New data has 8 point above control line.

Example of something which wasn't a control chart:

Dwarves in a mine:

A mining illustration



Figure 12. Seven dwarves from Snow White

Mine output

A common mistake for control charts

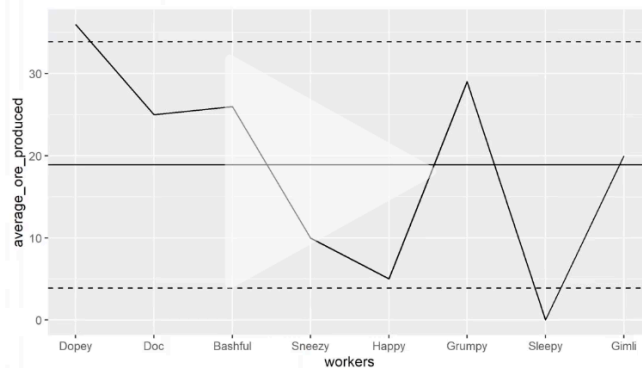


Figure 13. Inappropriate control chart

Why is this control chart bad?

- Worker chart has an arbitrary order
 - Control charts rules depend on a time sequence
 - Rules optimized for average run length
- Use ANOM chart instead

Average run length in manufacturing process. Want specific rules from observation. Cannot arbitrarily apply to different domain.

Framework for analysis of means:

Want to know if bone marrow measurements different between hospitals A B C D. What is pros and cons of ANOM vs Dunnitt's t test?

Dunnett's t-test compares all to a control. If hospital A is control then Dunnetts test better. ANOM does poorly when one of the groups is a control group. Look at 1 group vs. others then ANOM is not good, ANOVA followed by Dunnetts test better approach.

The ANOM hypothesis

$$H_0: \mu_i = \mu \text{ for all } i$$
$$H_1: \mu_i \neq \mu \text{ for at least one } i$$
$$\text{Reject } H_0 \text{ if } |\bar{Y}_i - \bar{Y}_{..}| > h(1 - \alpha, k, n(k - 1)) S_p \sqrt{\frac{k-1}{kn}}$$

The h percentile is like a t percentile

- Depends on number of groups
- No need to apply any post hoc test

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No J in ANOM. There is in ANOVA.

ANOM says there is a group different from the overall average. Find this group.

H percentile like t distribution but have to account for xxx.

There are K groups and making multiple comparisons. Different than each pair. There are 4 groups here vs 6 pairs we saw before. $n(n-1)/2 = 6$. 10 groups we look at pairs, $10*9/2 = 45$ possible pairs. The complexity of

ANOVA is square of num of groups. ANOM is linear, same as N, compare each group vs. mean.

H percentile on web.

ANOM h percentile already adjusted for multiple comparisons. No need to post hoc adjust for multiple comparisons.

ANOM table

	k=2	3	4	5	6
df=2	4.30	5.88	6.59	7.10	7.49
3	3.18	4.18	4.60	4.92	5.14
4	2.78	3.56	3.89	4.12	4.30
5	2.57	3.25	3.52	3.72	3.88
6	2.45	3.07	3.31	3.49	3.62
7	2.36	2.94	3.17	3.33	3.46
8	2.31	2.86	3.06	3.22	3.33

Have to adjust for group imbalance.

Please allow some time for video to appear below

Stop here if there are questions

What you've seen

- Framework for Analysis of Means

What's coming up

- A simple example

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not that bad but you have to adjust for

If different demographic groups differ from average can use ANOM if correct for imbalances.

Bottling plant example. Put labels on bottles.

Label placement



Figure 14. Six labeled bottles of bourbon

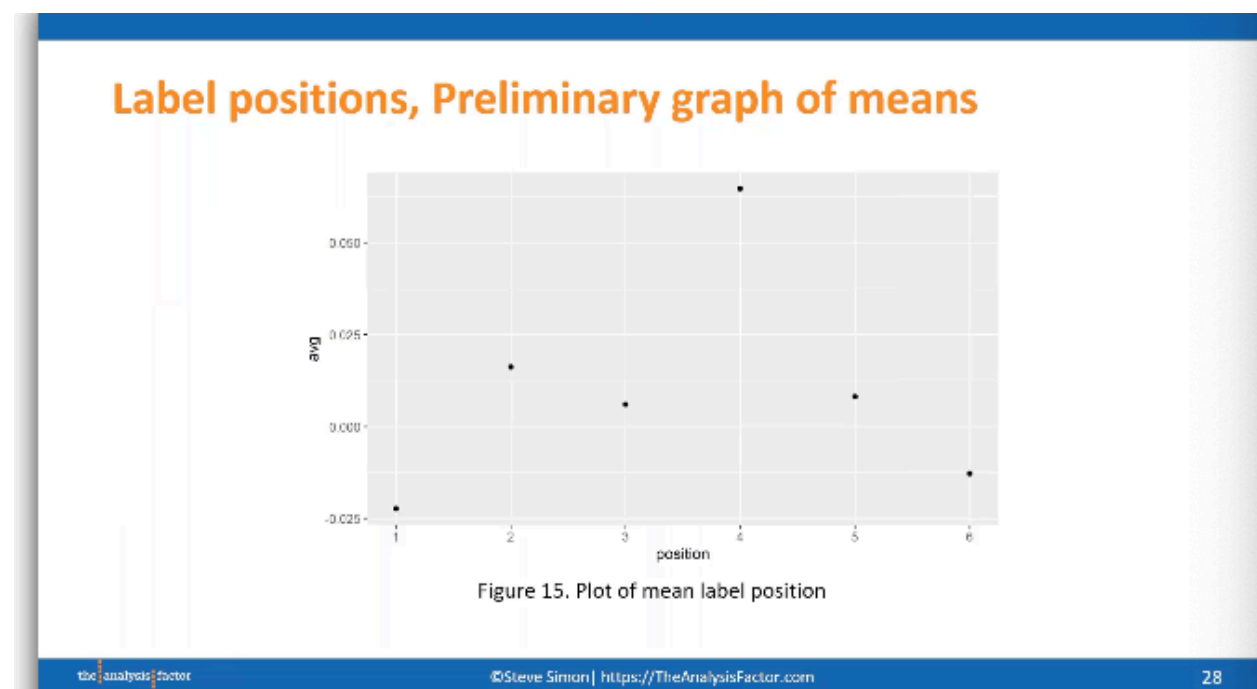
Label placement, descriptive statistics

	position	avg	stdev
1	1	-0.022	0.023
2	2	0.016	0.033
3	3	0.006	0.029
4	4	0.065	0.021
5	5	0.008	0.026
6	6	-0.013	0.016

so we look at um multiple labels I

Position 1 and 6 are too low. 4 is too high. Is 4 different from the overall average? How about 2,3?

Plot



Overall average is 0.01

Label positions, overall mean and pooled standard deviation

```
      avg      sp
1 0.01 0.025
```


Label positions, deviation from overall mean

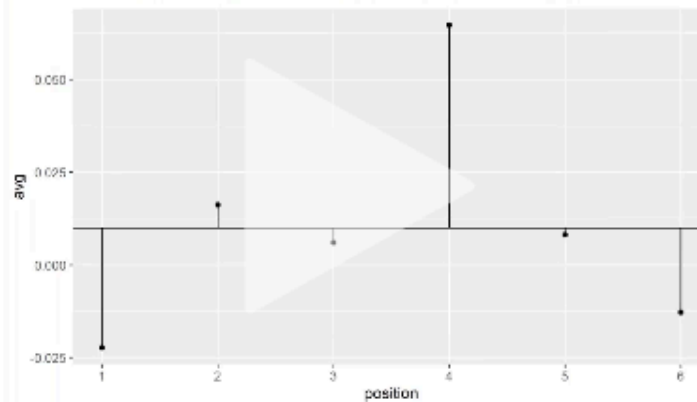


Figure 16. Plot of deviations from overall mean

mean it's slightly above zero so that

ANOM uses overall mean \bar{Y} and the h percentile. H percentage, k =Number of groups, 6, n =10.

39.44 what is alpha? .95?

Label positions, calculate ANOM limits

$$\bar{Y}_{..} \pm h(1 - \alpha, k, n(k - 1)) S_p \sqrt{\frac{k - 1}{kn}}$$

$$0.01 \pm 2.72 0.025 \sqrt{\frac{5}{60}}$$

-0.01 to 0.03

Draw the limit lines on the graph. 4 is above the limit lines and 1 and 6 are below the limit lines.

Label positions, add limits to graph

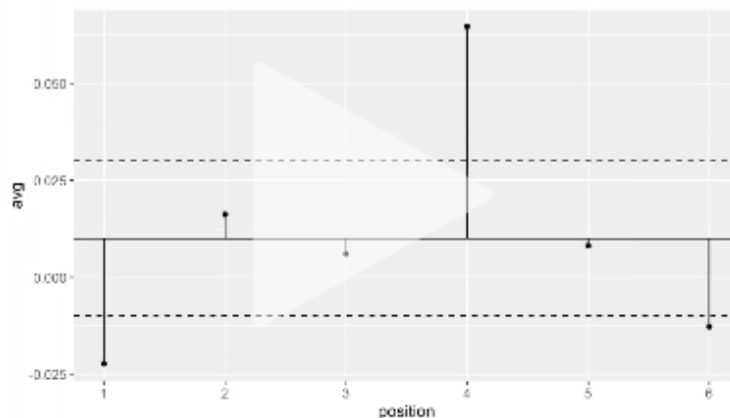


Figure 17. Plot with ANOM limits

ANOM can be used to see if you need a global calibration. Because the mean is straddled then no adjustment. But if on one side then calibrate with bias.

If you reject the ANOM hypothesis you make micro changes, if accept you make macro changes, ie calibrate everything up or down.

Stop here if there are questions

What you've seen

- A simple example

What's coming up

- Extensions to proportions and counts

C-sections

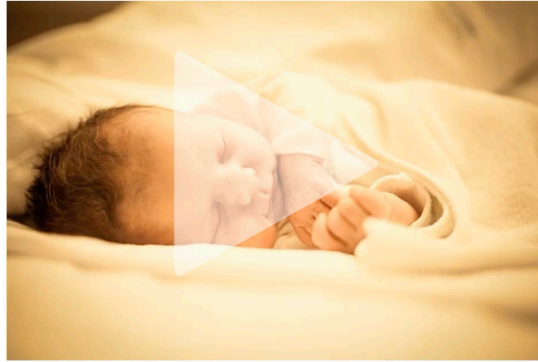


Figure 18. Image of newborn infant

Analysis of means for proportions

Two changes

- Proportions rather than means
- Unequal group sizes

Limits

- $\bar{p} \pm m(1 - \alpha, k, \infty) \sqrt{\bar{p}(1 - \bar{p})} \sqrt{\frac{N - n_i}{N n_i}}$
- IMPORTANT!!! Limits change with i

P bar Bernoulli dist. N is num observations across all clinics. n_i =num observations in i th clinic.

C-sections, first six observations

	group	c_sections	births	prob
1	1A	150	923	0.16
2	1K	45	298	0.15
3	1B	34	170	0.20
4	1D	18	132	0.14
5	3I	20	106	0.19
6	3M	12	105	0.11

C-sections, preliminary plot

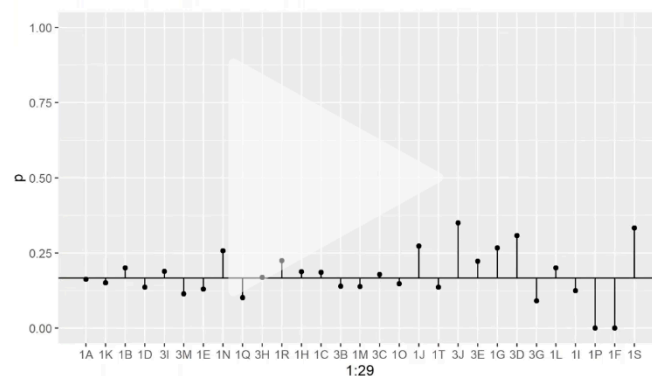


Figure 19. Plot of C-section proportions

C-sections, plot with ANOM limits

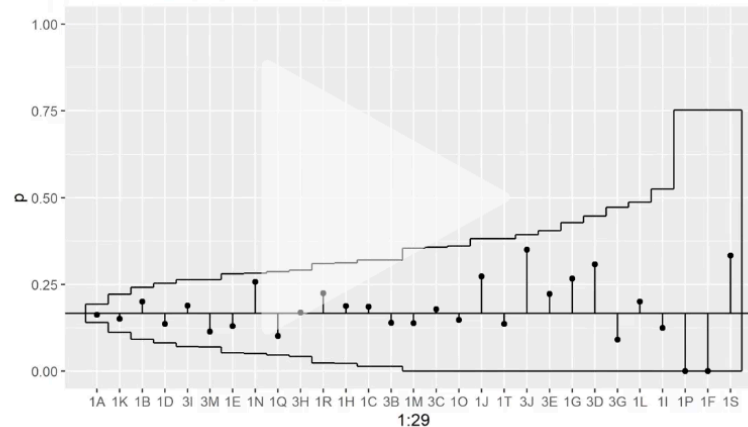


Figure 20. Plot of C-section proportions with ANOM limits

Even though some clinic have c section rate. As high as 25% all clinic in random variation; within envelope

Everything in limit so accept null hypothesis

Since null hypothesis accepted we make macro changes to all 29 clinics. Can we simulate this? 53.14 in video.

Can look at micro, clinics outside the anom envelope or macro at all clinics. This says look macro.

You can look at demographics and for health care there are disparities where some groups are provided worse health care ANOM will show this. Once you find an ANOM disparity then focus micro on the group.

